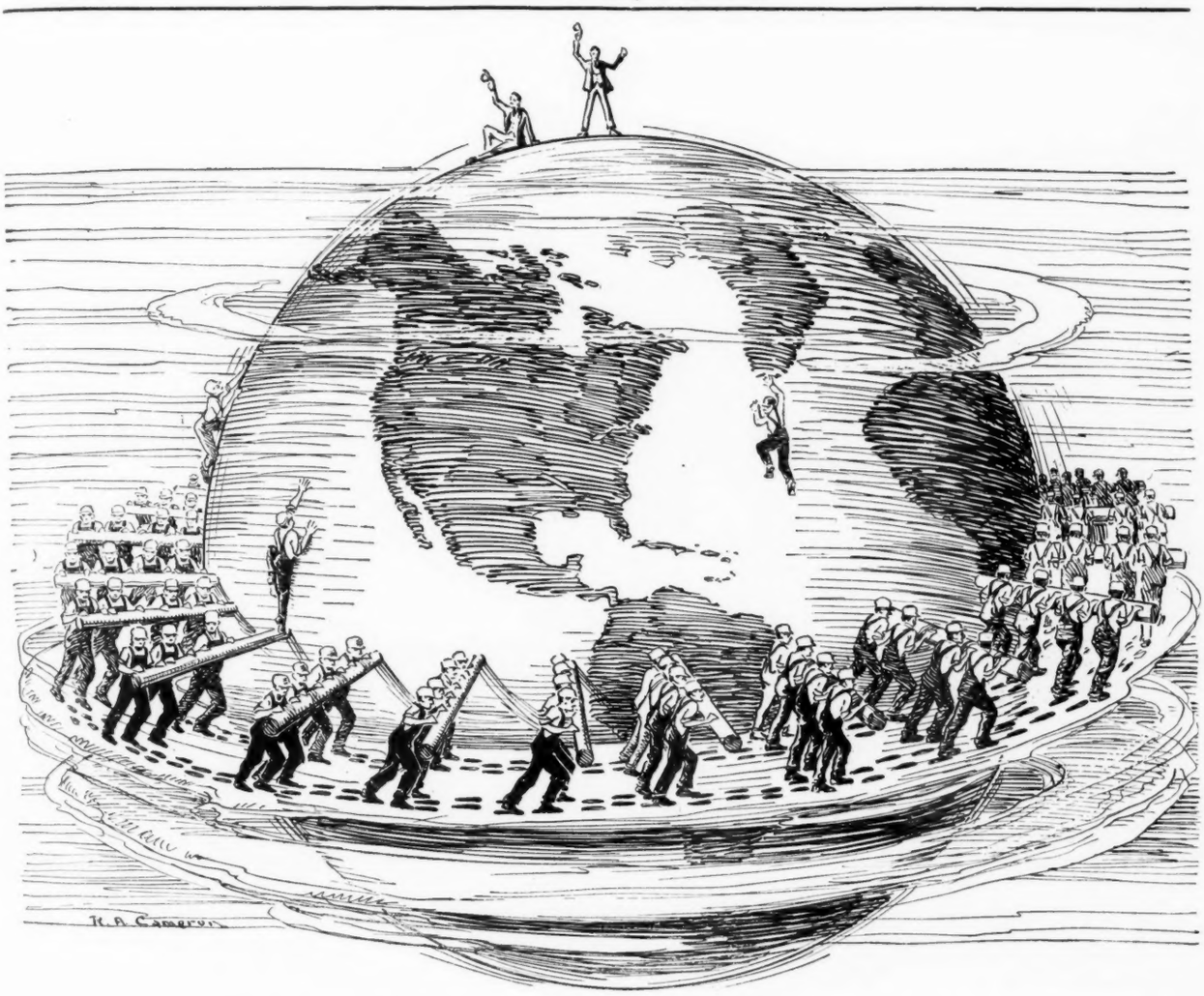
POWER

Volume 49 New York, May 20, 1919 *Number* 20



Ditto Marks and Distinction

By Rufus T. Strohm

There is nothing striking about a ditto mark except its frequent occurrence. It excites no curiosity and makes no strong impressions. It has no more character or individuality than twin tadpoles heading north.

Long ago some enterprising pusher of a quill invented it to save wearisome repetition and shorten his labor. When he got tired of writing "2 lb. of tea at so much" and "6 lb. of sugar at so much," it occurred to him to omit the units of measurement and to indicate them by a couple of commas.

He used the ditto to denote uniformity, and the badge of sameness still clings to it. It symbolizes commonplaceness. It is a confession of being on the same dead level with legions of others. It designates one of a multitude whose units are as much alike as the blades in a steam turbine.

There are numberless human ditto marks—men who have no points of difference from millions of their fellows. They are the chaps who do today the very things they did yesterday, in exactly the same way, and who expect to continue to the end of their existence in the selfsame rut. Their footprints merely parallel those of the day before.

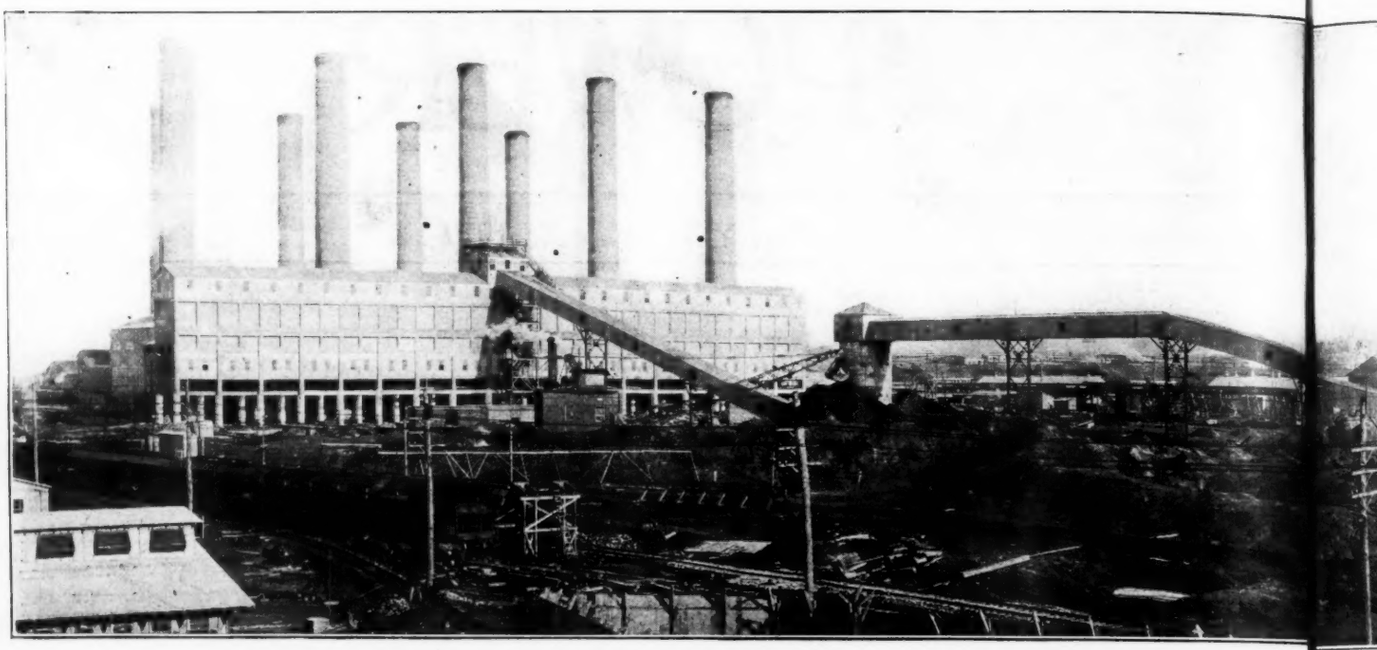
As soon as a man shows the ability to do something that no one else can do quite so well, he loses the mark of the ditto and acquires the insignia of distinction. He is no longer an indistinguishable atom in a mass. He is an individual.

No one ever wrote a ditto mark after the name of Watt, Stephenson, Fulton or Corliss. There was only one of each of them.

These men, together with thousands of others, escaped the stigma of being dittos because they made effective use of their brains. Instead of stagnating, they chose to progress.

The world is on the lookout for men who differ from the ordinary run because of special attainments, and its rewards are worth while. It offers a free field and plays no favorites.

Just how much longer are you going to be satisfied with being a ditto mark?



Power Installation at the Old Hickor Po

Mechanical equipment of the power station at the largest smokeless-powder plant in the world, erected in record-breaking time. The factors governing the design were speed of construction, low first cost, simplicity of operation and conservation of steel. The equipment includes sixty-eight 823-hp. boilers, fifty-two 350-hp. engines, 17,500 kw. in turbo-generators and thirteen ammonia compressors driven by uniflow engines.

JANUARY 29, 1918, the United States Government awarded to the du Pont Engineering Co. a subsidiary of E. I. du Pont de Nemours & Co., a contract for the Old Hickory Plant, which, as increased by a second contract, was to be the largest smokeless-powder plant in the world, with a rated average daily capacity of 900,000 lb., or 75 times as large as the largest smokeless-powder plant in the United States prior to the European war. Forty-one days later, and 29 days after ground was broken for it, the broad-gage track connection seven miles long had been completed to the site, and on Mar. 8 ground was broken for the plant. The site, sixteen miles from Nashville, Tenn., was at that time a level piece of farming land.

On June first, 84 days after breaking ground for the plant, the first operation—the manufacture of sulphuric acid—commenced, followed on June 23 by the purification of raw cotton; and on the same day, or 107 days after breaking ground, the first guncotton was nitrated. The first powder was granulated on July 2, or 116 days after breaking ground.

When the armistice was signed the entire plant was 93 per cent. completed, approximately $80,000,000 having been expended on construction. The speed with which the construction work proceeded may be judged from the fact that the rate of expenditure was 2½ times the rate of expenditure on the Panama Canal at its peak.

The built-up area of the manufacturing plant is 1800 acres.

The plant and village connected therewith cover an area approximately four miles by one mile, or an actual built-up area of 2360 acres.

Number of manufacturing buildings, 1112.

Number of buildings in village, 3667.

Population for which the village was designed, complete with water supply, sewage disposal, lighting, streets, sidewalks, stores, amusement facilities, etc., 30,000.

Miles of broad-gage track, 54.

Miles of plant industrial track, 32.

Maximum number of men engaged on construction, 33,170.

The conditions to be met in designing this plant were.

1. *Speed of Construction*—The serious shortage of smokeless powder made it necessary that every feature of the design be studied so that the maximum speed in securing materials and completing the construction work could be obtained. Everything else was subordinated to this feature.

2. *Low First Cost*—Because of the probable short time of operation, happily realized, the cost was to be kept at the lowest possible point consistent with satisfactory operation under the strained labor conditions existing. Permanency of structures was to be sacrificed, and operating savings were not considered unless the additional installation cost would be returned in one year's operation.

3. *Operating Simplicity*—To get the plant operating quickly, everything must be as simple as possible, thereby facilitating training of supervisors and labor.

4. *Conservation of Steel*—The minimum of steel was to be used because of the existing shortage.

*By E. A. Wardenburg, assistant chief engineer, Engineering Dept., E. I. du Pont de Nemours Co.

Powder Plant Near Nashville, Tennessee*

The estimated daily coal consumption was 5000 tons, including 420 tons per day used in the manufacturing processes direct. This coal was to be obtained from the western Kentucky field with a haul of 130 miles. The comparatively short haul combined with the precedence which this plant could secure on delivery and transportation made it possible to figure on a storage capacity of only 20 days' supply, or 100,000 tons. This, however, is a fair-sized coal pile, as it covers 6¾ acres piled 16 ft. deep, with allowance for the necessary tracks for handling.

Western Kentucky coal is likely to develop spontaneous combustion and should not be stored over 8 ft. deep. But this would have required such a large area for coal storage and such a large cost for handling equipment that it was decided to make the pile 16 ft. deep and submit to the cost of digging out fires as they occurred. It was also decided to store crushed coal, although provision was made in the design to store screened coal only if the firing was later found to be too serious. Before operations ceased, a pile of 90,000 tons had been accumulated and was on fire in several places, so that trouble was in sight, although the extra yearly cost of digging out fires was not determined.

The coal-handling plant decided on was worked out with the assistance of the Link-Belt Co., and is shown in plan in Fig. 1 and in elevation in Fig. 2. The headpiece shows a general view of the coal-handling equipment and the bunker. Coal is delivered on three tracks laid on a 1 per cent. grade with a sufficient length above and also below the dumping hoppers to hold 35 cars. It had originally been promised that hopper-bottomed dump cars only would be furnished for this service, and hoppers Nos. 1 and 2 covering tracks Nos. 1 and 2 were laid out for such cars spaced 44 ft. between centers. It was later decided by the Fuel Administration that hopper-bottomed cars could not be secured 100 per cent. of the time and a change was made on the second half of the plant, an extra hopper being added so that side-dump cars, dumping throughout their entire length, could be used, two cars on each track. Hoppers Nos. 3, 4 and 5 accordingly cover tracks Nos. 2 and 3 and are located 28 ft. between centers.

Each hopper is 27 x 27 ft. and delivers to a 42-in. apron feeder with a capacity of 150 tons per hour, which feeds the coal to a 36 x 36-in. two-roll crusher operating at 110 r.p.m. These crushers deliver to 24-in. belts operating at 300 ft. per min., each of which has a capacity of 150 tons per hour.

These belts convey the coal to the first set of inclined belts, which lift the coal to the top of No. 1 silo, a reinforced concrete tower 20 ft. in diameter and 43 ft. high. If the coal is to be delivered direct to the bunker—that is, without storing—it drops through the silo to the second set of inclined belts, to the top and down through silo No. 2 to the third set of inclined belts, which lift it to the top of the bunker, where, by means of the horizontal belts, each provided with a hand-movable tripper, it is delivered to any part of the bunker. Each of the inclined belts is 24 in. wide and at a speed of 600 ft. per minute has a capacity of 300 tons per hour.

If coal is to be stocked, it is diverted through a hole in the upper part of either silo, forming a pile from which it is dug by one of two cranes operating on a four-rail track having a figure-8 shape. Each crane is of 110 ft. radius and is provided with a 3½-ton bucket and has a designed capacity of 200 tons per hour. Coal being reclaimed is dug from any part of the pile desired and thrown against the silo, into which it passes through a hole in the lower part to a feeder that delivers it on one of the inclined belts for delivery to the bunker. The silos are of sufficient size so that in case it is later found necessary to store only screened coal, the crushers and screens can be installed in them.

The principal difficulty experienced with the coal-

handling system was with dust. The silos, conveyor runways and top of the bunker were very dusty, and it was necessary to shut down every day long enough to remove the fine dust that had settled, to prevent the machinery from being clogged. It is uncertain whether fully inclosed motors might not have been required.

The coal-handling equipment did not operate for a sufficient length of time to obtain maximum efficiency, but a record was kept for one month, during which time approximately 56,000 tons of coal were unloaded, 85 per cent. of which went direct to the bunkers and 15 per cent. to the stockpile. Considering the total number of men employed for the entire coal-handling equipment, including mechanics for minor repairs and adjustments, 385 man-hours were required per 1000 tons unloaded; however, this crew could have unloaded a considerably larger amount if there had been no delays in waiting for cars. During this time the following record was kept of the time required to unload various types of cars: Hopper-bottomed dump cars, approximately 50 tons, four men for 20 minutes; bottom-dump cars, approximately 40 tons, 8 men for 40 minutes; side-dump cars, approximately 50 tons, 8 men for 30 minutes.

The desire to keep down first cost led to the adoption of a bunker with a storage capacity of only about 24 hours, or 5000 tons. This was made of reinforced concrete to conserve steel and, as a matter of fact, at approximately the same first cost as steel. The bunker was located outside of the boiler plant so that its construction did not interfere with the erection of the boilers. Coal is delivered from the bunker to the boilers by electrically driven weighing larries with a capacity of 4 tons each. The height to the top of the concrete bunker is 63 ft. and to the top of the cor-

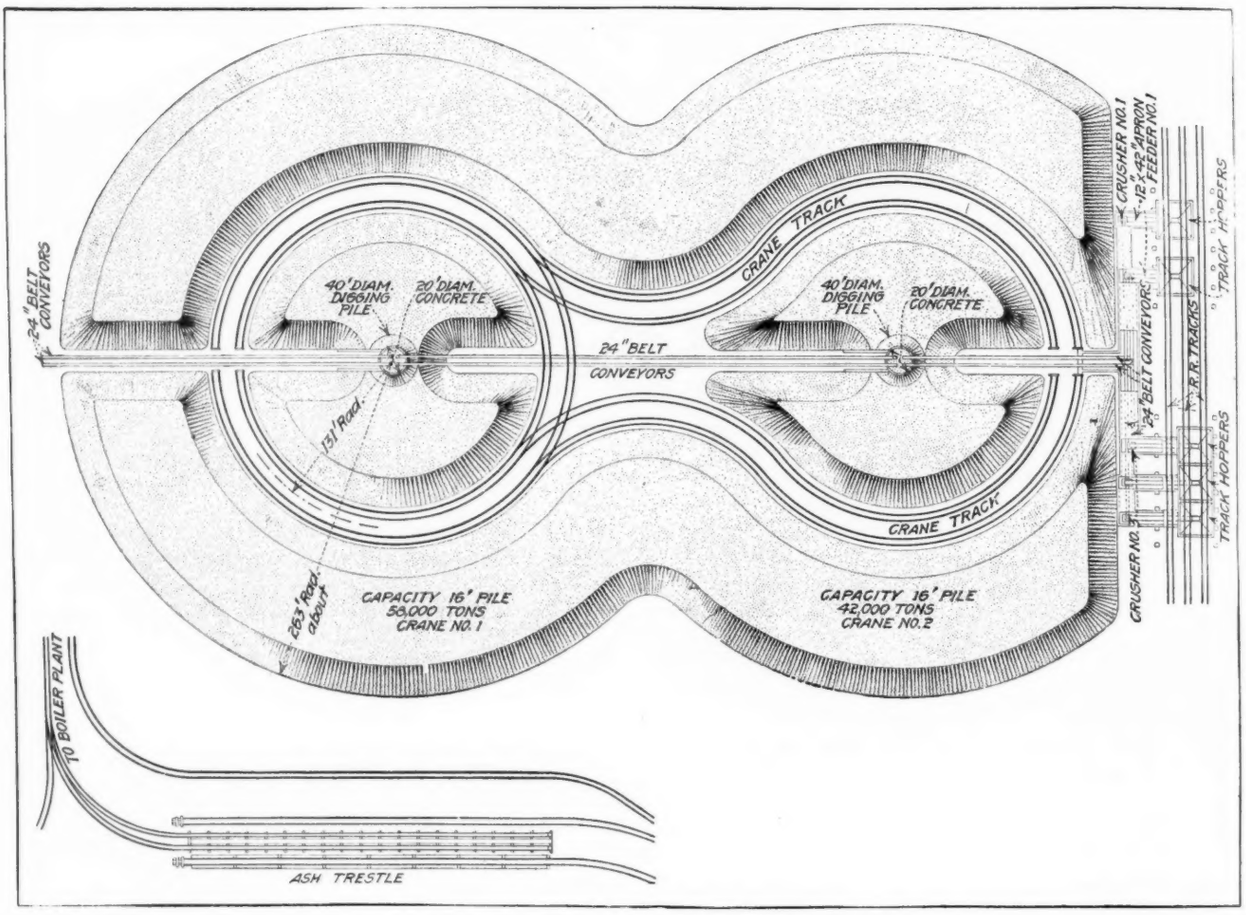


FIG. 1. PLAN OF COAL-STORAGE ARRANGEMENTS

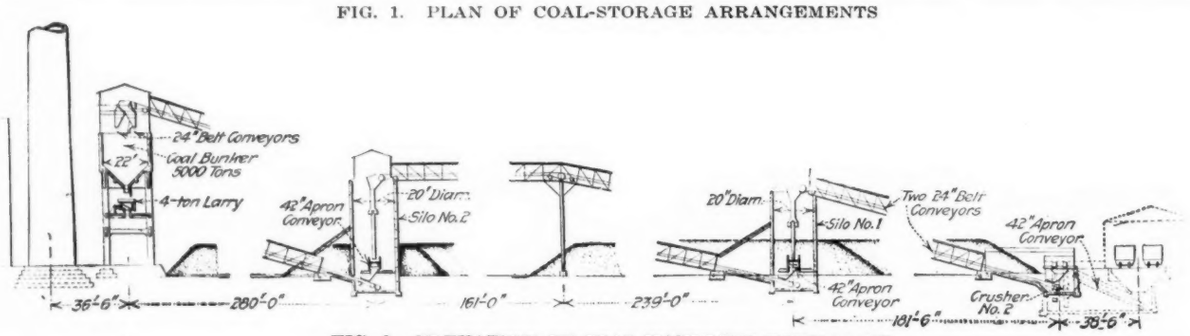


FIG. 2. ELEVATION OF COAL-HANDLING EQUIPMENT

rugated-iron building over the belt conveyors is 86 ft. The length is 414 ft., giving a capacity of 12 tons per foot.

It was anticipated that the boiler plant would present difficulties, with an estimated average load 24 hours per day of 86,000 boiler-horsepower at very close to 100 per cent. load factor and with the burning of Western Kentucky coal having a proximate analysis about as follows: Moisture, 6.5 per cent. (separately determined); fixed carbon, 55 per cent.; volatile matter, 31 per cent.; ash, 14 per cent.; sulphur (separately determined) 1.8 per cent.; B.t.u. per lb. of dry coal, 12,600; ash with a low fusing temperature.

It was decided to install boilers on the basis of operation at 175 per cent. continuous rating 24 hours per day and with 12½ per cent spares. As far as is known this is a higher 24-hour rating than has been used heretofore with a coal of such poor quality. It might be noted in passing that after the operating force was properly broken in, a full month's operation demonstrated that the designed rating could be secured without great difficulty. Fig. 3 shows a plan of the boiler plant giving also the steam-piping diagram, and Fig. 4 shows a cross-section through one of the boiler houses. There are five of these units side by side in the plant

There are sixty-eight 823-hp. class M-30 Stirling boilers set two in a battery with 8-ft. alleys. Eight boilers are connected by a steel breeching to a radial brick stack 15 ft. in diameter and 200 ft. high above ground level. The stokers are Westinghouse eight-retort. Three stoker engines are provided for each line of eight boilers, the two end engines for regular operation and the center engine for a spare for either set of four boilers. For a double line of 16 boilers there are 4 fans, each with a capacity of 110,000 cu.ft. per min. against 6 in. static pressure, delivering into

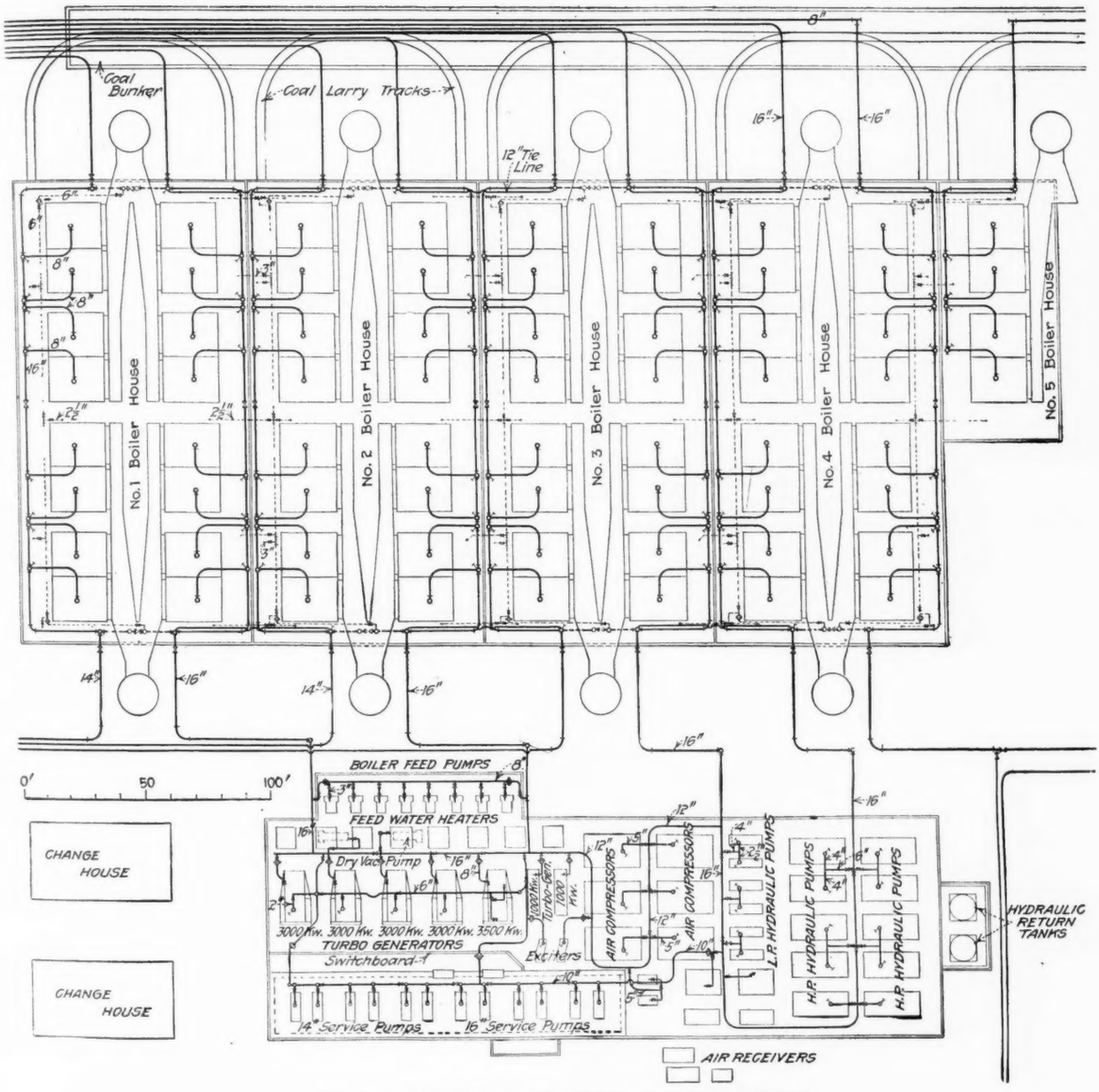


FIG. 3. PLAN OF STEAM PIPING IN POWER PLANT

a plenum chamber directly above. Each fan is geared to a 225-hp. Moore turbine. The fans are proportioned so that at full speed of 970 r.p.m. three fans will carry 14 boilers at 200 per cent. rating and two will carry 14 boilers at 140 per cent. rating. The boiler setting is shown in Fig. 4. Access to the furnace is through three doors in the bridge-wall to facilitate removal of clinkers. It was not determined whether this was actually justified or not, but probably it was not. The ash gate at first installed proved too light for the heavy clinkers obtained and had to be discarded. Fig. 6 shows the gate finally adopted, which proved satisfactory.

pressure desired for minimum radiation losses on long transmission lines. The cost of pipe lines also had a bearing on this decision—on the one hand the greater difficulty in securing a tight job with the higher pressure, and on the other the smaller sizes of pipe which could be used to deliver the required pressure at the operating buildings.

Feed water is hand-regulated, although if the plant had continued operation, automatic regulators would have been provided, the labor saving and additional security against high or low water justifying the installation.

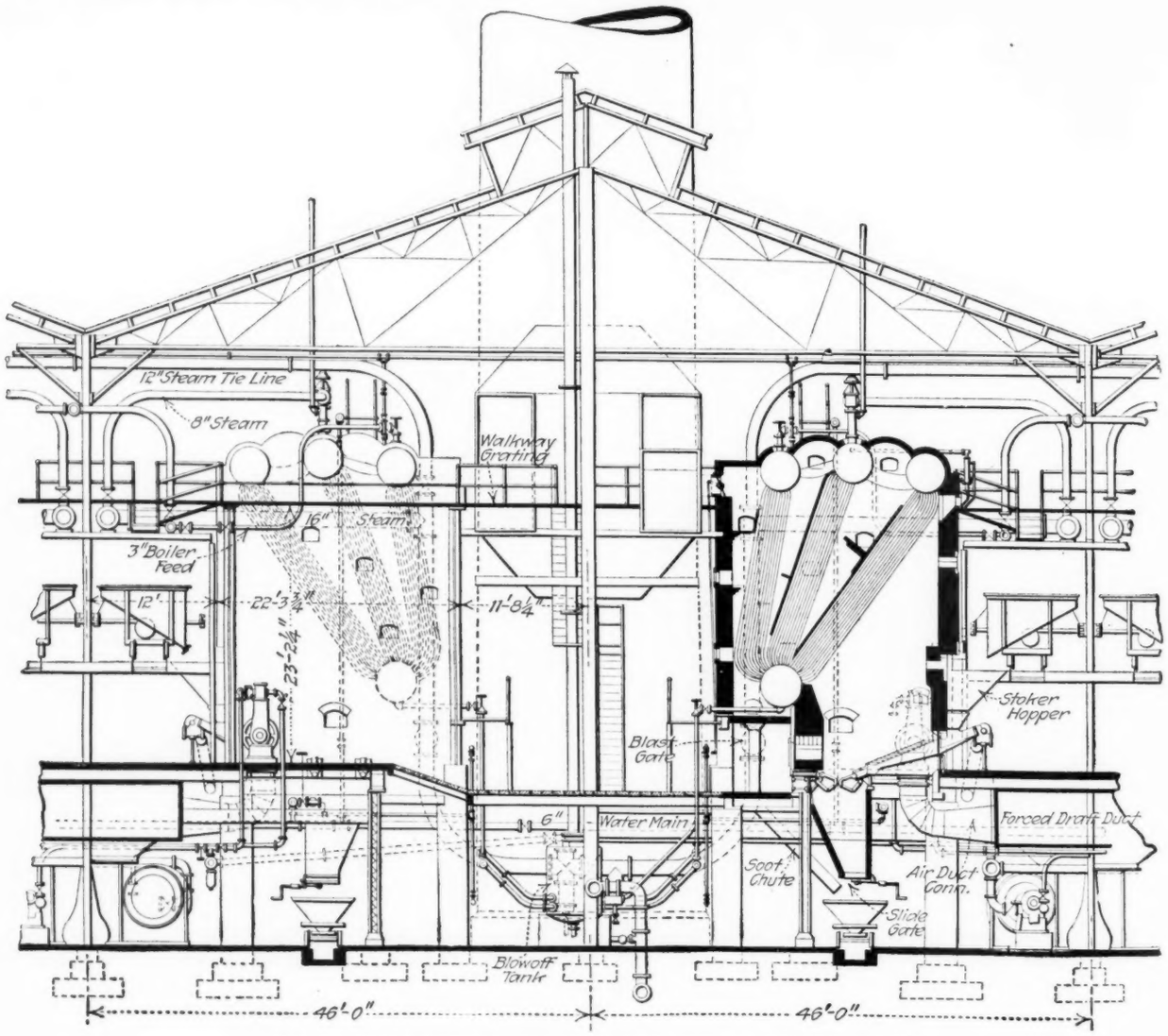


FIG. 4. CROSS-SECTION THROUGH ONE UNIT OF BOILER PLANT

Coal is supplied to the boilers by 5-ton electrically driven weighing larries operating at a speed of 500 ft. per min. and supplied with current at 110 volts to minimize the danger if a man should touch the contact rails. One larry could supply 16 boilers delivering 48 tons of coal per hour. Extension hoppers were provided for the stokers, each boiler having a capacity of 5 tons, or 1¾ hours, at 175 per cent. rating.

The plant was designed to carry an average steam pressure of 160 lb. per sq.in., this being a compromise between the higher steam pressure desired for economical operation of prime movers and the lower steam

Ground was broken for the boiler plant on Apr. 1, and 50 days later the first boilers went into regular operation. When the armistice was signed, seven months after breaking ground, 56 of the boilers with all equipment were entirely completed and the remaining 12 would have been entirely completed in two weeks more.

The building up from nothing of a highly efficient operating organization for such a large boiler plant is the work of years, and not of a few months. It is not surprising, therefore, that difficulty was experienced at first in maintaining the high rating desired. 175 per

cent., with coal far from good. During the last month of operation, however, this rating was secured without difficulty and with a fair over-all efficiency—approximately 68 per cent. Difficulty was also experienced with brickwork repairs, but with better operation of furnaces as the operators became more skilled, it was anticipated that these difficulties would have been much lessened.

Operation of a boiler plant at such a high rating and with such a small percentage for spares requires water of good quality. The Cumberland River water has an average mineral analysis about as follows:

	Grains per Gal.		Grains per Gal.
Calcium carbonate	3.26	Sodium carbonate	0.06
Calcium sulphate	0.13	Sodium sulphate	0.78
Magnesium carbonate	0.64	Sodium chloride	0.71
Silica	0.66	Volatile and organic	1.26
Iron oxide and alumina	0.52		
		Total solids	8.02

This water can be classed as reasonably good and it was not anticipated that difficulty would be experienced with it. The best criterion of a boiler water, however, is its action in the boiler. It was found that the one large boiler plant using this water, and with a returned condensate from surface condensers of 85 per cent., had so much trouble with boiler scale that a water-softening plant had to be provided for the 15 per cent. makeup water.

Because of the enormous size of the softening plant (7,000,000 gal. per day) it was decided not to provide this plant at first, but to watch the boilers very carefully. This decision was amply justified, the boilers being almost entirely free of scale. As a matter of fact, as far as the water surfaces were concerned, the boilers could have been operated for three-month periods.

The handling of ash is always a problem and at Old Hickory it was of unusual difficulty because of the amount of ash, which was estimated for full operation at 900 tons per day. A better idea of this amount may be secured by considering that this ash, dumped in a waste bank 10 ft. high, would have necessitated moving 650 lin.ft. of dump track 8 ft. sideways every 24 hours.

The ash hoppers under the boilers have a capacity for 7 hours' operation at 175 per cent. rating. From these the ash is dumped into side-dump cars of 40 cu.ft. capacity. Storage-battery locomotives haul trains of these over a level track onto a trestle, where the ash is dumped into broad-gage cars. Trains of these were to be hauled to the ash dump by a saddle-tank locomotive, although during the actual operation of the plant all the ash produced was used for roads and ballasting of tracks.

In the power house adjacent to the boiler plant are located the electric units, air compressors, hydraulic pumps, water-service pumps and boiler-feed equipment. Fig. 5 is a transverse section through the two-story part containing the electric units. The difference from the usual central station is indicated by the fact that whereas the boiler capacity installed would carry a continuous load of 175,000 kw., just 10 per cent. of this, or 17,500 kw., was the installed capacity at Old Hickory. This capacity is made up of two 1000-kw. Allis-Chalmers noncondensing, one 3500-kw. General Electric condensing, one 3000-kw. General Electric mixed-pressure and three 3000-kw. General Electric condensing turbines, all 60-cycle 2300-volt machines. Each of the condensing turbines is connected directly to a jet condenser in the basement beneath. These condensers draw injection water from one side of the service-water flume and discharge into the other side. This provides a continuous supply of condensing water and delivers warmer water to those portions of the plant which can use warm water satisfactorily. Each turbine pump is driven by a geared turbine, and two

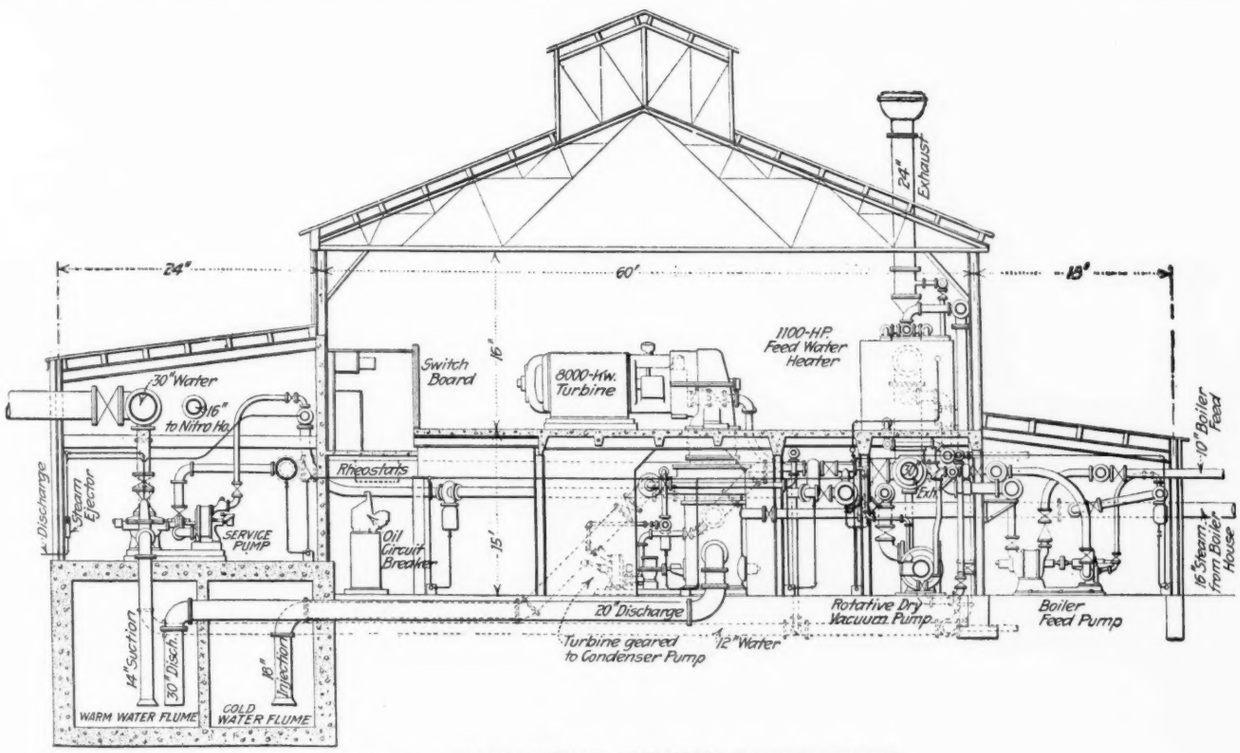


FIG. 5. CROSS-SECTION THROUGH POWER HOUSE

rotative dry-vacuum pumps serve the four condensers on the 3000-kw. turbines. With the two noncondensing machines and the mixed-pressure machine it was expected that almost an exact heat balance would be obtained the year round.

Three exciters are provided, two of 100-kw. capacity each, direct-driven by General Electric turbines, and the third a 75-kw. motor-generator set. With the simultaneous failure of two of the exciters, the remaining one can carry 70 per cent. of the total alternating-current load.

The switchboard, shown in **Fig. 7**, was designed for simplicity of construction. It is of slate and comprises 7 generator panels, 3 exciter panels, 1 regulator panel and 21 single circuit feeder panels. The oil switches are mounted on the wall back of the switchboard and are hand-operated through bell cranks. The outgoing circuits pass through an overhead concrete duct to a steel distributing tower outside the power house. General plant distribution is at 2300 volts with 440-volt motors and 110- to 220-volt lighting. For the river pumphouses, however, transmission is at 6600 volts from 2300- to 6600-volt transformers at the base of the distributing tower.

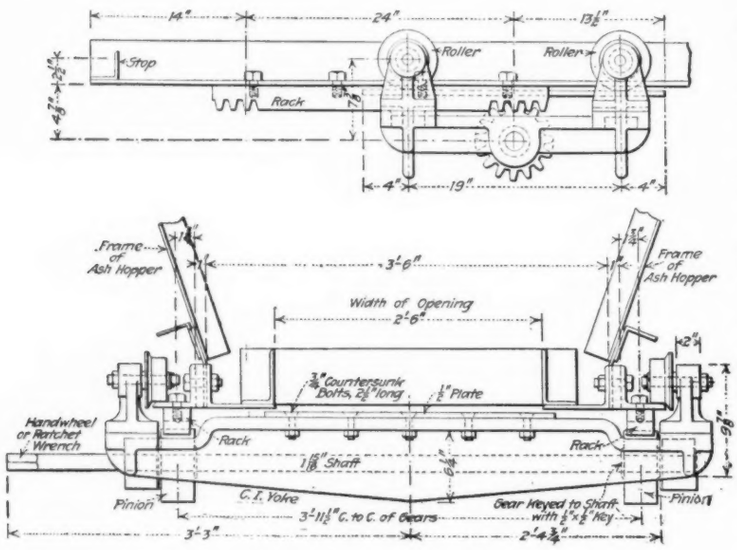


FIG. 6. DETAILS OF ASH GATE

Compressed air for general plant use, such as blowing acid, operation of acid pulsometers, etc., is supplied at 60 lb. pressure from six 15 and 26 x 20 x 24-in. compound steam, duplex air Laidlaw-Dunn-Gordon compressors with a displacement of 2570 cu.ft. each at 150 r.p.m. Compressed air for operation of shop tools is supplied at 110 lb. pressure by two 9 and 17 x 15 and 9 x 12-in. compound steam, compound air Laidlaw-Dunn-Gordon compressors having a displacement of 630 cu.ft. per min. each at 250 r.p.m. All these compressors exhaust to the feed-water heaters.

The fabrication of smokeless powder requires large amounts of water under pressure. The so-called high-pressure water at 3500 lb. pressure is supplied by ten 25 and 38 x 4⅝ x 24-in. Worthington compound duplex pumps with a capacity at 20 r.p.m. of 140 g.p.m. each. A better idea of the size of this pumping installation can be obtained perhaps from the fact that the estimated steam consumption with plant at full operation was 5000 boiler-horsepower. Connected to the high-pressure system are two 42 x 11½ x 50-in. hydro-pneumatic accumulators with a capacity of 22½ gal. each. These really act as pressure regulators, starting and stopping the pumps by cables attached to balanced steam valves on the pump supply pipes.

Low-pressure water at 300 lb. pressure for the first movements of presses is obtained from six 14 and 20 x 7½ x 18-in. Worthington compound duplex pumps with a rated capacity of 400 g.p.m. each at 29 r.p.m. These pumps are connected to a pressure tank, a float valve in which controls the steam supply to the pumps.

All the hydraulic pumps are piped to exhaust against 15 lb. back pressure for use in some of the plant operations, with sectionalizing valves so that some of the pumps can exhaust to the feed-water heaters in the summer time.

On the turbine floor are placed eight 11,000-hp. Warren-Webster feed-water heaters supplying feed water to eight 8-in. Alberger three-stage pumps having a capacity of 1050 g.p.m., or 15,000 hp. each, and each direct-driven by a 181-hp. Alberger turbine at 1900 r.p.m. The power house also contains 14 water-service pumps and two 1500-g.p.m. duplex Underwriters' pumps for maintaining pressure on the fire mains.

Fig. 3 shows the steam-piping diagram. It will be noticed that each kind of service is connected to at least three sections to avoid interruptions in case of failure of any portion of the steam piping. Every other system of piping was sectionalized in a somewhat similar manner. Ground was broken for the power house on Apr. 2 and one unit of each kind was placed in regular operation on June 17, or 75 days later. When the armistice was signed, seven months after breaking ground, the power house was complete in practically every detail.

The use of refrigeration for condensation of solvent vapors in the operation of recovering solvent from the powder made necessary the construction of a refrigerating plant of 3250 tons refrigerating capacity—larger than any other known refrigerating plant. This plant was built as a separate unit instead of as an adjunct to the power house, to reduce the cost of brine lines and avoid the presence of ammonia in the power house. There are thirteen 18 x 24-in. De La Vergne horizontal double-acting ammonia compressors each rated at 260 tons at 160 r.p.m. at a head pressure of 185 lb. and a suction pressure of 23 lb., corresponding to 20 deg. F. brine. Each compressor is direct-connected to a 370-hp. 23 x 24-in. Ames Uniflow engine.

The engines driving the ammonia compressors operate condensing by means of two Schutte & Koerting jet condensers. Water for these condensers is supplied by means of motor-driven pumps from the discharge from the ammonia condensers, the tail water flowing by gravity back to the plant for further use in the manufacturing operations, thus using this water three times. In connection with the refrigerating plant a 60-ton ice manufacturing plant was provided to take care of company hotels and commissaries and for cooling of drinking water.

The purification of guncotton and raw cotton requires enormous quantities of water—345 lb. water for each

pound of guncotton made—which must be practically free from turbidity, alkaline and not too high in mineral impurities. In addition, large quantities of water are required for cooling in acid manufacture, alcohol rectification and ether manufacture. This made the development of the water supply one of the major problems of the plant.

The Cumberland River, as is usual with southern rivers, is subject to heavy rises and records from previous years showed a flood stage of 55 ft. above low water, which was the rise for which the river pump-

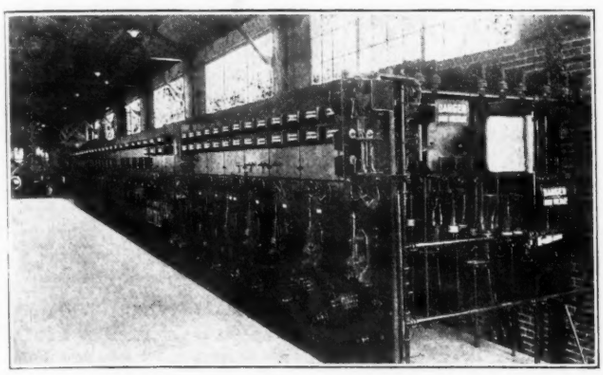


FIG. 7. VIEW OF SWITCHBOARD IN POWER HOUSE

houses were designed. There are two duplicate pumphouses, like that shown in Fig. 8, each containing five 14-in. Worthington pumps rated at 8500 g.p.m. each, at 112 ft. head and operating at 1170 r.p.m. Each pump is connected to a 300-hp. General Electric 2300-volt induction motor. In each house is provided space and foundation for a sixth pump and space by crowding and rearranging the stairway for a seventh pump. The estimated consumption of the plant for which these pumphouses were designed is 100,000,000 gal. per day, sufficient for a city of 1,000,000 inhabitants.

The services of the Foundation Company of America were secured to design the concrete details, and this company furnished a foreman to supervise the construction work. Construction was carried on by building a cofferdam of lock steel piling to bedrock and dewatering the site. The soil and loose rock were removed and keys cut into the solid rock to prevent sliding. The work was flooded out twice, causing a loss of several days until the river receded sufficiently to allow of dewatering and starting work again.

In a sump below the floor line is a vertical pump with a capacity of 400 g.p.m. and driven by a vertical shaft by a motor above the flood stage. This pump is provided so that in case of a leak or break in a pump casing the pumphouse could be drained without too serious a loss of time. It also takes care of any leakage, which is, as a matter of fact, almost completely absent. A fan is provided to blow fresh air to the bottom of the structure to displace the air warmed by the motors. This is a necessity for summer operation.

The pumps discharge into a 36-in. header from which two 42-in. risers are taken. The four 42-in. risers from the two pumphouses combine into three 42-in. wood-stave mains which deliver the water to the plant 8000 ft. away.

On top of the concrete structure and housed in a light corrugated-iron structure are three 600-kw. transformers to reduce the voltage from 6600, which is the transmission voltage from the plant, to 2300, the motor voltage. There are two 6600-volt lines following entirely different routes from the plant to minimize possibility of interference by any accident.

Power to drive guncotton pulping and poaching machinery and also for the machinery in cotton purification plants is furnished by 52 Allis-Chalmers Corliss engines, 18 x 36 in., rated at 350 hp. each at 120 r.p.m. Steam from these engines is just sufficient to heat the water required in the process. The use of engines instead of motors for this work resulted in a very large saving in both installation cost and operating cost.

The outside piping systems, to distribute such large amounts of power over such a large area, can best be appreciated perhaps by the following figures, which are for main lines and do not consider branches:

	Total, Feet	Total Miles
Steam mains (of which 24,000 ft. is 16-in.)	176,000	33
Compressed-air mains	58,000	11
Water mains, excluding fire mains	110,000	21
Fire mains	180,000	34
Brine mains	56,000	11
Hydraulic mains (including high-pressure, low-pressure and return)	36,900	7
Total main lines		117

In the steam distribution for the cotton purification plants and for the guncotton plants headers are run from which branch lines are taken to each unit and into which steam is fed by lines from the boiler plant. The whole system is sectionalized so that the failure of no section can result in the shutdown of more than two out of the nine units. Expansion is taken care of by changing the elevation with long-radius bends or by inserting an expansion joint made up of long-radius bends and straight pipe sections approximately every 500 ft. It will surprise many, no doubt, to know that the radiation loss from this extensive system with a maximum transmission of 6400 ft. and with pipe covering about an inch thick is well under 5 per cent.

These distributing systems, together with the enormous amount of piping of all kinds in the various

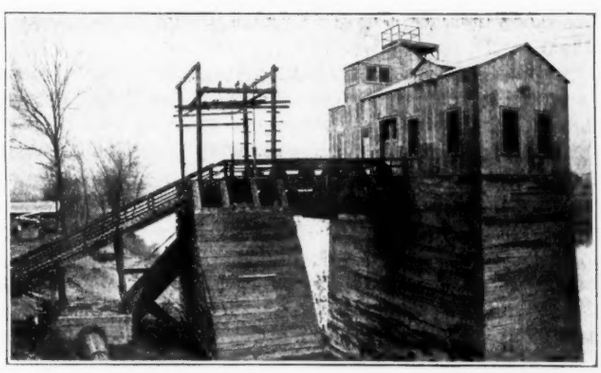
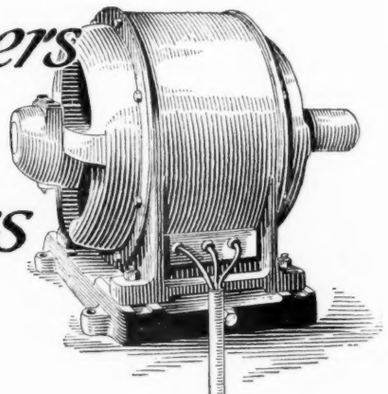


FIG. 8. PUMPHOUSE, SHOWING CONCRETE FOUNDATION

manufacturing buildings and power plant, constitute perhaps the largest single piping job ever undertaken. The work was carried on by the organization and manufacturing shop of the B. F. Shaw Co., which were taken over temporarily by the du Pont Engineering Co.

This article would not be complete without a word of appreciation for those manufacturers who, with shops full of other work and confronted with great difficulties in securing labor and materials, nevertheless turned out as fast as required the equipment that made it possible to complete the power installation in record-breaking time.

Size of Transformers for Induction Motors



By

J. B. Gibbs*

The practical electrician and the operating engineer are frequently confronted with the problem of determining the size of the transformers to specify for a given size motor. This question is discussed and methods are given for solving the problem to meet a variety of conditions that occur in practice

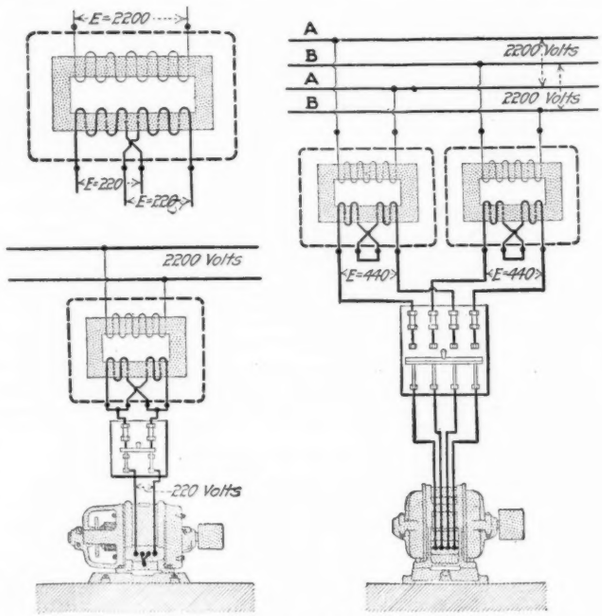
IN SELECTING transformers to be used with induction motors, there is a large field for the use of good judgment. The transformers must not be too small, or they will burn out when the motor is loaded. If they are too large, it means unnecessary energy losses in the system and unnecessary investment in the transformers. So it is important to know what should be expected of motors and transformers and how to group them.

Probably the most common case will be where a motor wound for 220 or 440 volts is to be run from a power line at 2200 volts. Transformers for this kind of service are built in two classes. The first class has its low-voltage winding divided into two parts, which may be connected in series for 220 volts, or in parallel for 110 volts. The second class has the low-voltage winding in two parts, which give 440 volts when connected in series and 220 volts when connected in parallel. Fig. 1 shows the development of the winding of a transformer for 2200 to 440 or 220 volts.

The size of transformers to be used with a given motor depends on several factors. According to the Standardization Rules of the American Institute of Electrical Engineers and of the National Electric Light Association, transformers are designed to have a temperature rise of 55 deg. C, above the surrounding air when carrying continuously the load indicated on the name-plate. The reason for this is that if a transformer is located in a hot place (45 deg. C. or 113 deg. F. is taken as the standard air temperature), and loaded, the coils will reach 45 + 55 = 100 deg. C., which is as high a temperature as the insulation should be called upon to stand continuously.

*Engineer, Transformer Department, Westinghouse Electric & Manufacturing Co.

Now a motor rarely has an absolutely uniform load, and short-time peaks much above the rating of the transformers will be harmless if the load between the peaks is correspondingly low. Usually, unless the installation is important enough to warrant a test of actual load conditions, the best that can be done is to estimate the size of the transformers required from the size of the motor, and then to inspect them at intervals for a few days or a few weeks to find whether



FIGS. 1 TO 3. DIAGRAMS OF TRANSFORMER AND INDUCTION-MOTOR CONNECTIONS

Fig. 1—Upper left-hand corner; diagram of transformer connections. Fig. 2—Lower left-hand corner; diagram of single-phase motor connected to transformer. Fig. 3—On the right; diagram of a two-phase motor connected to two transformers.

they are getting too hot. If any doubt exists as to the transformers to use, it is better, of course, to err on the side of safety.

Another thing that sometimes causes uncertainty is the difference in the way of rating motors and transformers. Motors are always rated in horsepower or in kilowatts—usually in horsepower—while transformers

are always rated in kilovolt-amperes. With direct-current motors the product of the volts by the amperes gives the power in watts actually put into the motor; but with alternating-current motors this is not true. With alternating-current motors the product of volts by amperes must be multiplied by another factor, called the "power factor," to give the watts. That is, if two motors to which is being supplied the same amount of power at the same voltage, one alternating current and the other direct current, the alternating current will require more current than the direct-current machine. And since it is current and not power that heats the transformers, they must be large enough to take care of this extra current. The transformers must also supply the losses that take place in the motor itself, which makes them still larger.

Methods for approximating the correct size of transformers for various conditions are given in what follows. They are based on the assumption that the motor will carry about full load and will have an efficiency and power factor as good as a typical modern induction motor. The simplest case of alternating-current motor connection is a single-phase motor, as shown in Fig. 2. Two wires are run from the secondary of the transformer through fuses and a switch to the motor. Small motors are usually connected to the lighting circuits and treated as a part of the lighting load, but the larger sizes are likely to cause flickering of the lights, and are therefore better run from separate transformers. Single-phase motors are built in sizes ranging from a small fraction of a horsepower up to about ten horsepower. The approximate size of transformer for a single-phase motor may be found from the formula,

kv.-a of transformer = *hp. of motor* × 1.25

In most cases where power is required, it can be better supplied by polyphase motors than by single-phase motors, because the former are cheaper, have better operating characteristics and are more sturdy and reliable. As a rule, the larger the motor the higher will be both its power factor and efficiency. High-speed motors generally have better power factor than slow-speed motors, and 25-cycle motors have better power factor than corresponding 60-cycle motors. As a rough general rule, which is easy to remember, it may be said that each horsepower of the motor rating will need one kv.-a. of transformer rating. The figures given in what follows are somewhat closer than this, but in order to use standard transformers it will often be necessary to select them larger or smaller than indicated by the figures.

Fig. 3 shows a two-phase motor connected to a two-phase line. In this case two transformers are needed, as shown, and the size of each, if the motor is small (say 25 hp. or less) may be taken as

kv.-a of one transformer = *hp. of motor* × 0.58

For large two-phase motors, say 100 hp. or more, the size of transformers may be found from the expression,

kv.-a of one transformer = *hp. of motor* × 0.46

In operating three-phase motors from three-phase lines, we have a choice of several connections. Fig. 4 shows the open delta, or "V" connection, which is frequently used, especially for motors of the smaller sizes. In this connection the current in the transformers is out of phase with the voltage, so a larger total kv.-a of transformers is needed than with the delta connection. On the other hand, only two units are needed instead of three, and this is an advantage in installation. For small motors connected as in Fig. 4 the size of each transformer may be found from the formula,

kv.-a. of one transformer = *hp. of motor* × 0.67

and for large motors,

kv.-a of one transformer = *hp. of motor* × 0.53

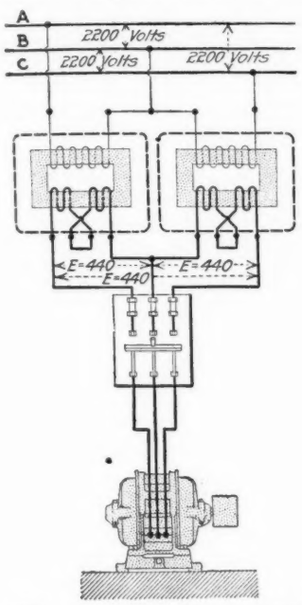


FIG. 4. THREE-PHASE MOTOR CONNECTED TO TWO TRANSFORMERS IN OPEN-DELTA

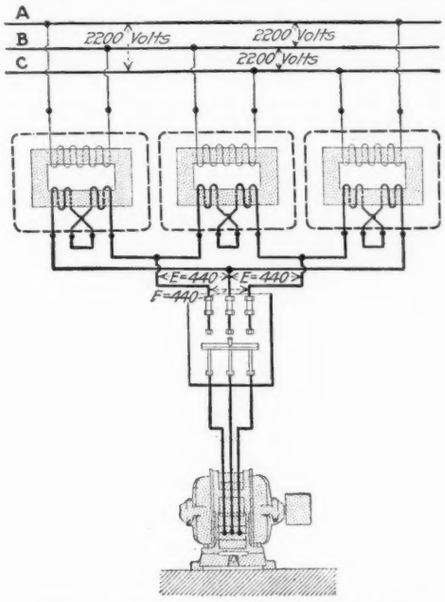


FIG. 5. THREE-PHASE MOTOR CONNECTED TO THREE TRANSFORMERS IN CLOSED-DELTA

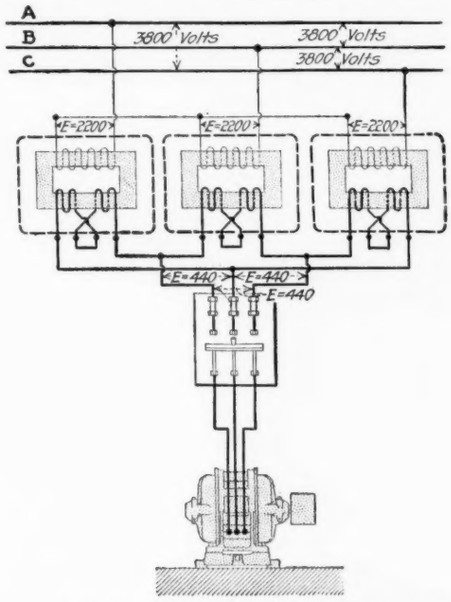


FIG. 6. THREE-PHASE MOTOR CONNECTED TO THREE TRANSFORMERS STAR TO DELTA

The delta connection, shown in Fig. 5, is also much used for transformers supplying three-phase motors. One advantage of this connection is that in case of trouble with one transformer it can be cut out, and the remaining two transformers will operate in open delta and allow the motor to carry about 58 per cent. of its normal load. The size of the transformers for small motors is,

kv.-a of one transformer = *hp. of motor* × 0.39

and for large motors is,

kv.-a of one transformer = *hp. of motor* × 0.31

Another connection frequently used is the star, or

"Y," connection, shown in Fig. 6. It is especially convenient where it is desired to run three-phase motors from a three-phase 3800-volt line, using standard 2200-volt transformers. One high-voltage terminal of each transformer is connected to a common junction, and the remaining three terminals are connected to the three line wires, as shown. The size of transformers needed is the same as for the delta connection given in the foregoing.

Sometimes it is desired to operate two-phase motors from a three-phase power line, or vice versa. The usual connection for this case is shown in Figs. 7 and 8. Two transformers are needed, and the three-phase side is provided with special taps. Fig. 7 shows a two-phase motor connected to a three-phase line. The "main" transformer, shown at the left in the sketch, has a lead brought out from the middle point of its high-voltage winding, and this lead is connected to an

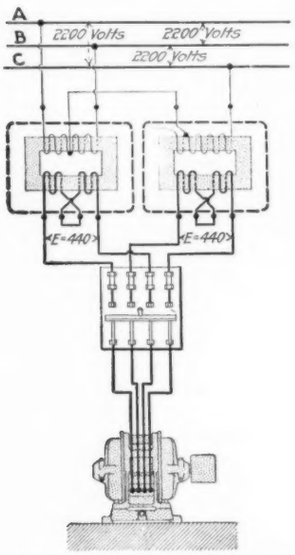


FIG. 7. CONNECTIONS FOR OPERATING A TWO-PHASE MOTOR FROM A THREE-PHASE LINE

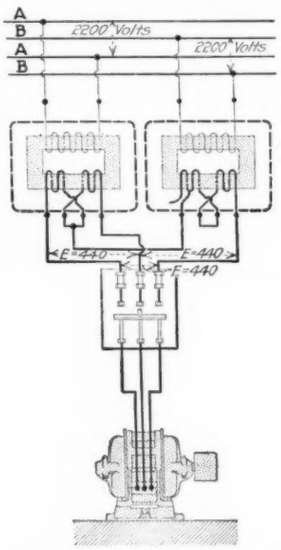


FIG. 8. CONNECTIONS FOR OPERATING A TWO-PHASE MOTOR FROM A TWO-PHASE LINE

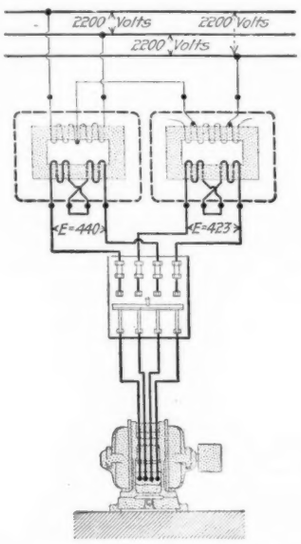


FIG. 9. CONNECTIONS FOR OPERATING A TWO-PHASE MOTOR FROM A THREE-PHASE LINE

86.6 per cent. tap on the "teazer" transformer. The other end of the teazer winding is connected to the three-phase line. This causes the voltages in the secondary windings of the two transformers to be 90 deg. apart and equal in magnitude; that is, to be two-phase voltages. The connection of a three-phase motor to a two-phase line is shown in Fig. 8. In this case the special taps are in the low-voltage windings, in the same relative positions as above. For small motors connected according to either Fig. 7 or Fig. 8 the size of transformers is

kv.-a of one transformer = *hp. of motor* × 0.67

and for large motors,

kv.-a of one transformer = *hp. of motor* × 0.53

Small motors are started by closing the main switch and connecting the motor directly to the line, as shown in all the figures, but for large motors this would cause too large a rush of current, so some kind of starting device, or "compensator," is used. This is connected between the motor and the main switch and usually consists of auto-transformers, or choke coils. There are several kinds of compensator on the market, and as a diagram of connections always accompanies the compensator, they are not included in the figures given here.

The direction of rotation of a single-phase motor can be reversed by interchanging the leads of the starting winding or running winding on motors of the split-phase type or by shifting the brushes on motors of the repulsion type. The details of this operation depend on the arrangement of leads, and instructions are always sent with the motor. Two-phase motors may be reversed by interchanging the two leads of either phase, and three-phase motors may be reversed by interchanging any two leads.

A volume might be written on the subject of emergency connections, because there are so many possible emergencies, but the operator must always depend finally on his own judgment and knowledge. It may be of assistance in forming a judgment in any particular case to point out certain facts and relations.

Two transformers can usually be connected in parallel to give an output equal to the sum of their ratings.

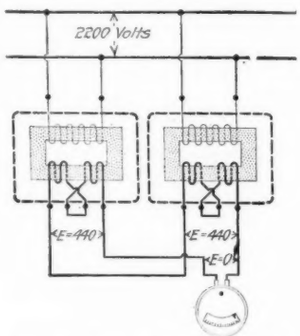


FIG. 10. METHOD OF CHECKING PARALLEL-CONNECTED TRANSFORMERS

This is true especially if the two transformers were built by the same manufacturer and are not too far different in size. For instance, a 10-kv.-a. transformer would probably operate satisfactorily in parallel with a 5-kv.-a. or a 25-kv.-a. or any size between the limits, but it might be doubtful wisdom to connect a 5-kv.-a. in parallel with a 100-kv.-a. unit. In some cases the characteristics of large transformers are such that they will not divide the load in proportion to their ratings when connected in parallel. This merely means that the output of the bank is limited by the transformer which takes more than its share. In case of doubt it is well to ask the manufacturer whether the two transformers in mind are suitable for operation in parallel, although this is seldom necessary for transformers smaller than 100 kv.-a.

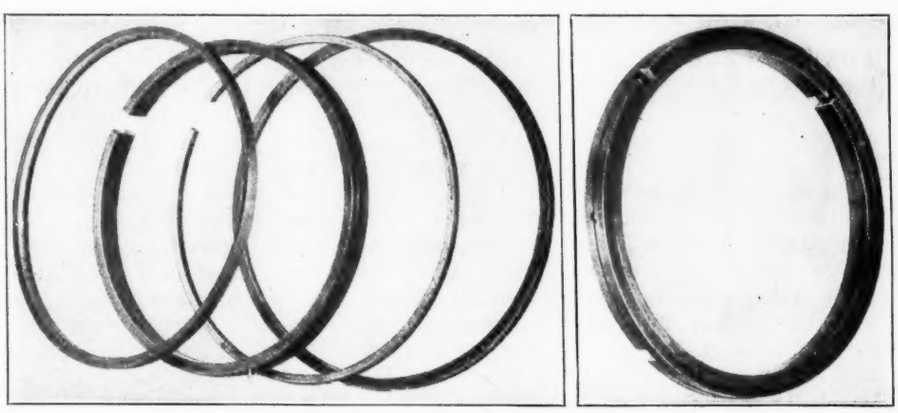
In making a parallel connection between transformers it is always well to check their polarity, especially if they were made by different manufacturers. This may conveniently be done as shown in Fig. 10. Connect one transformer to the primary and secondary lines, as shown at the left of the sketch, and connect the other transformer to the primary line and to one side only of the secondary line. Now take a voltmeter, or incandescent lamps, and test between the open side of the transformer and the other secondary line wire as shown. If no voltage is indicated, the connection is correct and may be completed. If the voltmeter shows

a reading or the lamps light, the leads of the second transformer must be reversed. If lamps are used for this test, enough should be connected in series to take up double the voltage for which the transformers are connected.

Two-phase motors may sometimes be run from three-phase lines using standard transformers. For the "main" transformer select one which has its primary wound for 2200 or 1100 volts, series-parallel, and for the "teazer" transformer one which has two 5 per cent. taps in the primary. These are both standard arrangements, and the ordinary central station usually has both kinds. The two transformers are connected as shown in Fig. 9. This gives a two-phase voltage which is unbalanced and which consequently puts the motor at a disadvantage; but it will enable the motor to run and may sometimes save a long delay in getting the proper special transformers.

Du Bois Piston Ring for Internal Combustion Engine

A piston ring designed for internal-combustion engine pistons is shown in the accompanying illustrations. It is of the composite type and is formed by a plurality of rings, coacting to produce a tight packing ring. The carrier, or bull ring, has an outer annular groove in the central plane of the ring, which forms the seat for an inner expansion ring. Both rings have gaps adapted to form a straight joint. The carrier also forms an expansion ring the action of which is more limited than that of the inner expansion ring, owing to the difference in construction.



ASSEMBLED RING AND RING PARTS

Packing rings are mounted to encompass the carrier ring and the expansion ring. Each of the packing rings has on its inner face a bevel against which the expansion ring bears, and acting on the bevels tends to move the two packing rings apart on the carrier ring. As the separation of the packing rings is limited by the width of the piston-ring groove, the expansion ring will also control the lateral expansion of the packing rings if the carrier fails to sufficiently expand the packing rings laterally. The result is a longitudinal and lateral motion.

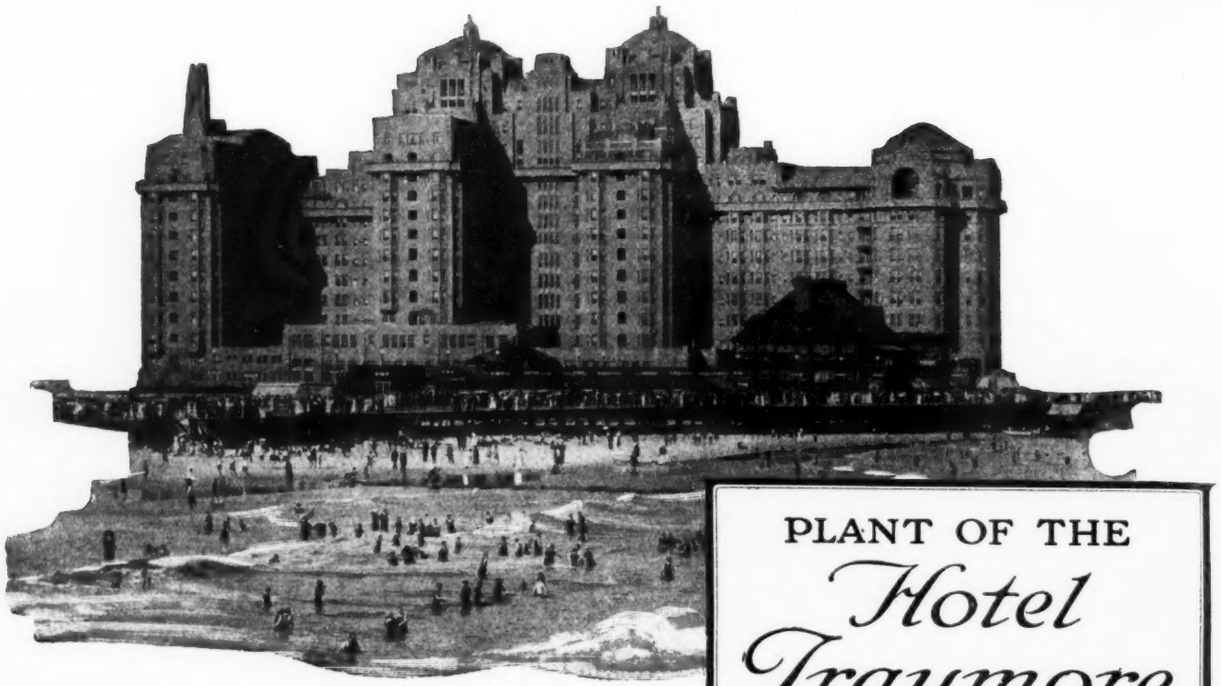
The bevels of the rings are at angles of 45 deg. to the bearing faces of the packing rings, which are made either corrugated or smooth. The gaps in the packing rings may form a straight joint, or a lap joint may be used if so desired. The packing rings are provided with elongated notches in the proximate faces, into which enters a pin which is anchored in the carrier ring; the pin also passes through the gap of the expansion ring. The pin is set at an angle of 135 deg. to the gap of the carrier ring, and the notches in the packing rings are formed at oppositely directed angles of 45 deg. from their notches. Therefore the joints of the packing rings are 90 deg. apart, and one of them is 180 deg. and the other 90 deg. from the joint of the carrier, giving the best lateral expansion.

In cases where it is desirable to dispense with the carrier ring, a seat for the expansion ring is provided directly in the piston groove, for which purpose a groove is depressed from the bottom of the groove. The packing rings are also, if desired, reduced at their upper outer faces to provide space for secondary packing rings, the gaps of which rings have straight joints. The secondary packing rings present as much working surface as the primary rings which carry the secondary rings.

In this construction of composite rings, the elongated notches in the adjacent faces of the packing rings engage the pin, which is in this case anchored in the expansion rings at an angle of 135 deg. from the gap therein. The relative rotation between the primary and secondary packing rings is controlled by pins anchored in the primary packing ring and which are located in the gap of the corresponding secondary ring. The pins are so mounted in the primary rings that the gaps of the secondary rings are at an angle of 90 deg. from one another. These predetermined positions give the best lateral action.

The ring, which is manufactured by Frederick Du Bois Blauvelt, New York City, is designed to take the place of a plurality of piston rings used at present, and to provide a composite ring particularly adaptable for internal-combustion engines having high compression and slow speeds. It is made for cylinders from 5 to 30 in. in diameter.

Ohio reports that millions of tons of coal are on fire on lake port docks from spontaneous combustion indicate that we are reaping one of the fruits of war hurry, says the *Wall Street Journal Straws*. An industrial coal expert explains that during the war everything was coal, the good, bad and worse, and as such was dumped indiscriminately at lake ports. In this way much coal with high sulphur content was dumped in big piles. The action of water on the sulphur in the coal piles forms crude sulphuric acid. This, in turn, generates heat and causes combustion. Water, except in great quantity, is useless in fighting coal fires. Going to the heart with a steam shovel alone settles the question. Apprehension is expressed that the lake coal situation, owing to the big tonnage that is involved, may prove to be extremely troublesome as well as costly.



PLANT OF THE *Hotel Traymore*

JUST what does it require in light, heat and power to care for the necessities, conveniences and comforts of the guests of this beautifully imposing palace in America's greatest all-year playground, Atlantic City, N. J.? The Traymore is, in general, patterned after a castle on the Killarney Lakes of Ireland. There is a total of 900 rooms, including 700 guest rooms with baths; 1400 guests could be conveniently accommodated, though 1100 is the usual maximum. One travels far before seeing such impressive architecture.

The hotel stands on the beach. The engine room is on the ground level, the boiler room being 4 ft. below sea level. There are six 200-hp. water-tube boilers in three batteries. These are handfired and carry 125 lb. pressure with no superheat. Buckwheat No. 1, 50 per cent., and Lykens Valley buckwheat No. 2, 50 per cent., is used at present.

The boiler-furnace walls and boiler tops are covered with 4½-in. insulating brick and plaster. The flue-gas temperature is plotted by a recording pyrometer, the CO_2 is recorded, and control of combustion is guided in part by combined draft gages, known widely as a "boiler efficiency meter." The firemen are negroes trained by the watch engineers. Typical CO_2 charts show that combustion results usual in this plant are equal to those had in large industrial and central power plants where high-set boilers with stokers are the rule. The heat for the whole hotel—that is, for the light, power, heating, steam for the laundry and the kitchen—comes, of course, originally from the coal. The coal consumption in winter averages about 800 tons per month and in summer about 600 tons.

CHIEF ENGINEER GEORGE W. ARMITAGE

Up to this writing the water has not been accurately metered, and no scales, automatic or otherwise, are regularly used, therefore accurate data upon which to determine the boiler performance are not available. Coal scales and a water meter likely will soon be installed. Roughly, however, about 8.5 lb. of water per pound of coal as fired was the average evaporation during 1918. The combustion chambers and tubes are cleaned monthly.

The stack, or natural, draft is 0.75 in. in the furnace. For burning the mixture of Nos. 1 and 2 buckwheat coal, a steam blower is used.

No city water is used in the hotel. Fresh water is had from two wells, each 850 ft. deep, the water being raised by air lift with 80 lb. pressure on the wells and 100 lb. on the supply tank. The air is compressed in two-stage compressors shown in Fig. 2. Air for the operation of the thermostatically controlled valves in the heating system is furnished from the main supply tank mentioned, through a reducing valve. For lighting and power one 125-kw. and two 250-kw. Corliss engine-driven direct-current generators are used. The power voltage is 220, the lighting

voltage 110, motor-generator balancer sets being used. The average load through the day is 500 amperes, 1100 to 1200 amperes at night, 220 volts. One of the 250-kw. generating sets is shown in Fig. 2. Tests conducted on these units gave the following results:

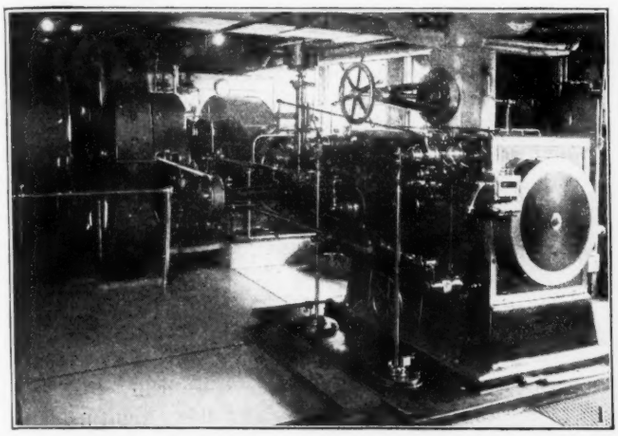
Indicated horsepower at 1060 amp., 225 volts	356.85
Friction load, horsepower	15.7
Efficiency of engine and generator, per cent	86.6
Steam consumption 1 horsepower-hour, lb.	19.0
Pressure, lb. gage	115.0
Back pressure, lb. gage	Atmospheric
Speed, r.p.m.	112.0
Clearance, per cent. estimated	3.0

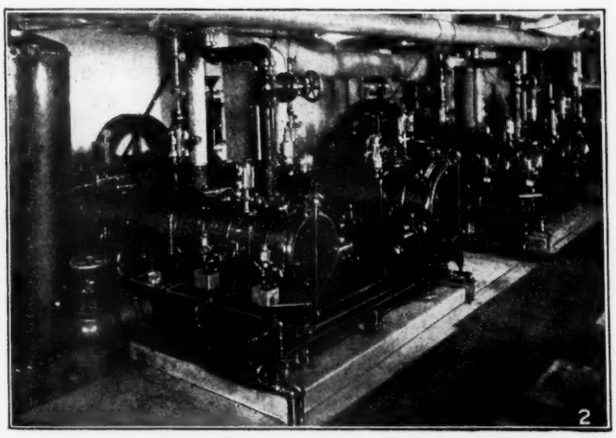
The switchboard is shown in Fig. 4.

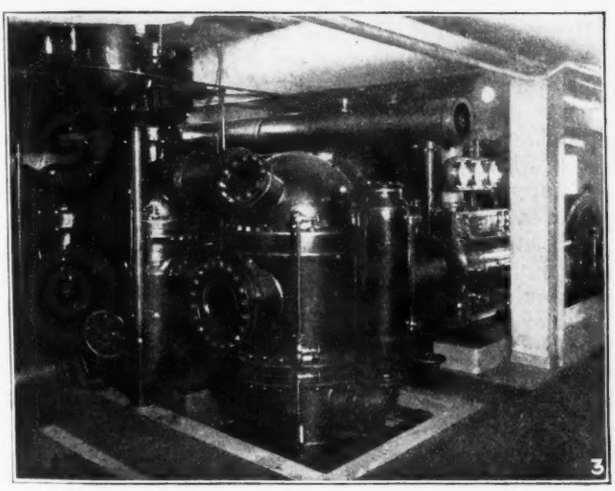
All large elevators are of the hydraulic plunger type. The plungers are 11¼ in. in diameter, the chambers being of the large pot type with 5½-in. diameter soft-rubber valves.

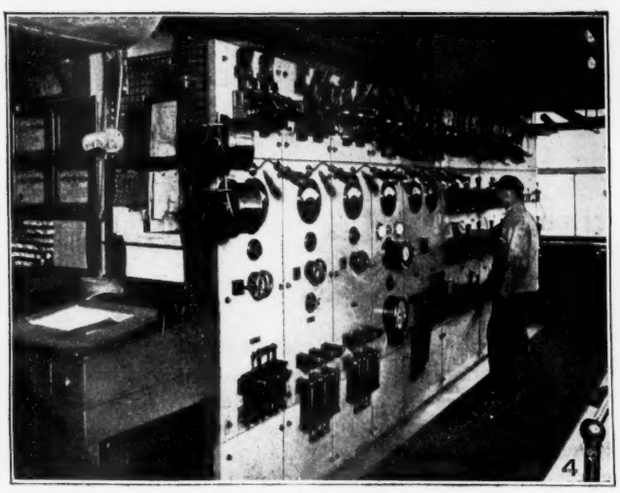
Two relay pumps are used, each 18 and 28 x 14 x 24-in. of the American Pump Co. type.

Exhaust steam is the medium used for heating the building. There is a total of 65,240 sq.ft. of radiating surface, chiefly in 1600 radiators; to distribute the steam 220 risers are used. For a time after the opening of the hotel 15-in. vacuum was maintained in the returns owing to a rise and fall in several of the lines. This rise has been eliminated by the chief engineer and









FIGS. 1 TO 4. VIEWS IN THE ENGINE ROOM, HOTEL TRAYMORE

Fig. 1—One of the 250-kw. Corliss engine generating sets. Fig. 2—Showing the two-stage air compressors. Fig. 3—View of the water end of the high-duty elevator pump. Fig. 4—The switch board.

There are ten for passenger service, one for the kitchen and one chair lift. Two passenger cars go to the top floor, the length of the 6½-in. plunger on each being 225 ft.; the other passenger cars have 6½-in. plungers, each 180 ft. long. The service cars have 5½-in. plungers. The operating pressure is 160 lb. and the pilot pressure is the same. There are eight counterbalance cables to each car.

The high-duty, outside-packed elevator pump is driven by a three-cylinder compound engine—one 18-in. diameter high-pressure cylinder, each low-pressure 24-in., stroke 24-in. The steam consumption per indicated horsepower was 19.9 lb. on tests under the same operating conditions given for the engine of the generating set. This pump was specially designed for the service at hand; a view of the water-end is shown in Fig. 3. now but 6-in. vacuum is required. One with experience with large heating systems appreciates how such a reduction has decreased air leakage into the systems and other troubles arising from carrying a high vacuum on a heating system.

The steam supply to the radiators is at the top, through a vapor valve. Exhaust steam does not issue from the hotel except on some days during July and August, all of it being demanded for use within the building. The laundry uses considerable. In addition to exhaust steam, the laundry uses some live steam supplied to it through a 4-in. pipe. Worth-while reduction in the use of live steam by the laundry has been effected by the removal of several small live-steam pipes formerly used to heat water in open tanks. Heedless use of this steam resulted in much waste of it. The water

is now heated in a tank under control of the engineers. For refrigeration, ice making and cooling drinking water two horizontal double-acting ammonia compressors of 25 tons each are installed.

A total of 54 boxes are cooled, and about 5 tons of ice is pulled daily. There is can capacity for 13.5 tons in 100-lb. cans. The drinking water is maintained at 40 deg. F. Double-pipe condensers are provided. The circulating water for use in these condensers is taken from the artesian wells, to which it is returned after passing through the condenser.

The vacuum cleaning machines, of which there are two, are of the Palm inclosed horizontal type, each driven by a 10-hp. motor. Each has capacity for handling 800 cu.ft. of free air per minute.

The visitor to this plant is impressed with the unusually smooth operation of the equipment. This is vitally essential to the success of a hotel power plant. Though

FIG. 5. BOILER ROOM, HOTEL TRAYMORE

practically all of the machinery in the Traymore's plant is reciprocating, there is such a marked absence of sound from it, that, standing near the entrance to the engine room, only the initiated ear would know it was there by the intermittent hiss of water rushing through the hydraulic relief valve of the elevator pump.

The concrete floor of the plant is covered with a well-known preparation. The writer was impressed by the absence of dust from the floor and with absence of oil around the pans under the valve gear of the Corliss engines.

Price & McLanahan, of Philadelphia, were the architects; the heating system was installed by William M. Anderson, Philadelphia. The engines, elevator pumps, elevators, tanks, etc., were designed and built by the Robert Wetherill Co., Chester, Penn. George W. Armitage is chief engineer.

Shipment of Power-Plant Equipment

BY M. A. SALLER

While the average manufacturer or purchaser of power apparatus is concerned with specifications, guarantees, details of construction, etc., it frequently happens that little attention is given to proper shipments and packing.

Probably the first point of importance is making shipment and delivery on scheduled time, especially on new construction work, where it is necessary to place one piece of equipment after another, and where frequently one appliance cannot be put in position until another line of equipment is installed. Delay may hold up dependent work, cause a change of plans and scaffolding at considerable extra expense or make it necessary to leave unfinished some parts of the building walls in order to admit the delayed equipment.

Freight shipments and routings are also important. If a plant is situated on a railroad siding, where facilities are available for removing the equipment from cars with cranes, the shipments should be sent over that particular railroad; if routed over another line it will be necessary to pay transfer charges or haul the equipment from another freight station.

The shipment of heavy machinery in high-sided gondolas is a source of embarrassment and expense when the crane capacity is not available for lifting the material vertically from the cars. Shippers of heavy machinery should use flat cars unless it is known that the purchaser can handle the material satisfactorily from a high-sided car.

The shipper should make sure that the apparatus is firmly attached to the car so that it cannot work loose in transit. This will avoid broken or bent parts due to shifting of the apparatus.

Sometimes the manufacturer will forward apparatus which is not complete; that is, make a partial shipment without notifying the customer specifically just what has gone forward and what is to follow. Confusion and delay are then bound to occur when the purchaser begins to erect the apparatus and finds certain parts missing. When partial shipments are made the manufacturer in every case should notify the customer as to what parts are missing and when they will follow. The purchaser should also be notified when shipment is made, over what routing, etc., but in many cases the manufacturer is remiss on these details.

It is rarely possible to ship power-plant equipment complete and erected. In most cases the fittings and small parts are packed in crates or boxes accompanying the main unit. Each box, crate or detached part should be marked with the proper order numbers and identifications so that the box or part can be identified even if it becomes detached from the main shipment en route. Some manufacturers follow the excellent policy of making up a detailed packing list showing the number of each box or package with an itemized list of the parts or fittings contained therein.

It is a notorious fact among power-plant equipment erectors that the detailed directions and instructions for the erection and installation of the equipment often never reach the actual operating force, but are retained in office files or in the storeroom. Manufacturers should arrange to send complete directions by mail to the purchaser, and also include such directions with the actual shipment so that they are available to the erecting men on the ground in case the instructions previously sent do not reach them.

Innumerable complaints are received by shippers and manufacturers to the effect that parts of shipments, fittings or other items are "short." In a great many of the cases the shortage is the result of oversight or a mistake at the source of the shipment; but experience has shown that oftentimes the reported shortage is due to carelessness or lack of system in unpacking or perhaps to theft. When excelsior is used in packing care must be taken that no small parts are thrown away with the packing material.

Horsepower Requirements of Centrifugal Pumps

By T. M. HEERMANS*

Horsepower requirements as related to motor drive. How to figure it, including the power to lift the water and overcome friction and velocity heads and the allowance made for pump efficiency. Starting torque, types of motor used and motor troubles traceable to the pump.

BEFORE attempting to show why one centrifugal pump needs a 100-hp. and another a 50-hp. motor, or why a squirrel-cage motor is best for some conditions and not for others, it might be well to consider a few fundamental relations as affecting the horsepower required to do pumping work with this kind of pump.

A centrifugal pump raises water by the rotation of a runner in a properly designed casing which is first filled with water, or primed, before pumping can begin. As may be seen in Fig. 1, the runner is mounted centrally in the pump casing and fastened to the shaft which extends out of the casing for connection to the driving motor or engine. When the shaft is rotated, the water in the pump is forced from the center outward by the runner and into the discharge passage, while more water is drawn up into the pump to take the place of that displaced, thereby making the pumping continuous. The energy given the water by the runner is sufficient to raise it to some height and discharge a certain quantity, depending on the speed of the pump, the diameter of the runner and its design. It can be seen, therefore, that work is done by lifting this quantity of water to the given height.

CONSERVATIVE EFFICIENCIES FOR PUMPS OF VARIOUS CAPACITIES

Size of Pump, In.	Normal Capacity, G.P.M.	Efficiency Single-Stage Heads Up to 150 Ft., Per Cent.	Efficiency Multistage Heads Above 150 Ft., Per Cent.
2	100–150	50	45
3	200–350	55	50
4	400–600	60	56
5	650–900	65	62
6	950–1300	70	68
8	1500–1800	72	70
10	2000–3000	75	72
12	3500–4500	76	73
14	5000–6500	77	74
16 and over	.....	78	75

The amount of useful work done is known as the water horsepower and is equal to the weight of water lifted a certain number of feet in a definite length of time. Since pump capacity is usually expressed in gallons per minute (g.p.m.), and a gallon of water weighs 8⅓ lb.,

Work done per minute = *g.p.m.* × 8⅓ *lb.* × *feet head*,

and as one horsepower is equivalent to lifting 33,000 lb. one foot in one minute, water horsepower,

$$W.\,hp. = \frac{g.p.m. \times 8\frac{1}{3} \times feet\ head}{33{,}000} = \frac{g.p.m. \times feet\ head}{3957}$$

In the preceding formulas the head not only consists of the height the water has to be lifted but also includes the head lost by friction in the piping and the head required to make the water flow through the piping at a given rate; that is, the total head equals the static lift plus pipe friction plus velocity head. The driving motor, therefore, to turn the runner at the required speed must be able to develop the water horsepower the pump takes, and in addition there are losses in the pump to be overcome.

Briefly, these losses in the pump are the friction of the water in the casing on the outside of the revolving runner, leakage and other hydraulic losses on the inside of the pump, and bearing and stuffing-box friction. These losses have to be added to the water horsepower to find out the horsepower actually needed to run the pump and the size of motor required for the drive. The ratio of the water horsepower to the actual horsepower required to run the pump gives the pump efficiency, which pump builders have to determine from actual tests, because the pump losses cannot be figured out absolutely beforehand.

Consequently, although the water horsepower can be figured easily, it will be necessary to have some idea of the efficiency of different sizes and kinds of pump before the actual horsepower to specify for the driving motor can be determined. The efficiencies in the accompanying table are conservative and can be used in estimating the horsepower required for well-designed pumps operating at suitable speeds against moderate heads.

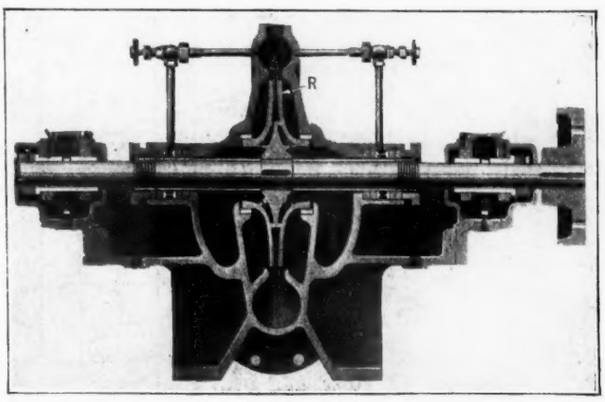


FIG. 1. CROSS-SECTION OF SINGLE-STAGE CENTRIFUGAL PUMP

R is the rotating element, and the arrows show direction of the water through the pump.

As an example, in figuring the horsepower required to drive an 8-in. single-stage pump designed to deliver 1500 g.p.m. against a total head of 100 ft., use the formula for water horsepower previously derived and divide the water horsepower by the pump efficiency given in the accompanying table, that is, horsepower required by the pump is:

$$Hp. = \frac{g.p.m. \times feet\ head}{3957} \div pump\ efficiency = \frac{1500 \times 100}{3957} \div 0.72 = 52.6$$

As computed in the last paragraph the horsepower is known as the actual figured horsepower required by the pump, but a motor somewhat larger should be selected, say the nearest standard rating, which is 10 to 12 per cent. greater than the brake horsepower figured. In the case worked out, therefore, a 60-hp. motor would be recommended. There are several reasons for giving

*Mechanical Engineer, Centrifugal Pump Dept., Allis-Chalmers Manufacturing Company.

motors this slight margin of horsepower over that actually figured.

In the first place the runners of commercial centrifugal pumps cannot be turned out easily to the thousandth of an inch in the cast passages without unduly increasing the cost. Consequently, in fitting pumps with runners for a given condition, the size of the runner openings are made a little large to allow for slight inaccuracies of manufacture and to make sure that the pumps will test out slightly over capacity. This usually is not objectionable to the purchaser, as very few complaints are made because a pump discharges more than the guaranteed quantity, provided the motor is not overloaded. A margin allowed in figuring the motor, therefore, will prevent its being overloaded should the pump be slightly over capacity. It is also true that runners, after being used for some time, may become worn, causing the runner to handle more water, and although this water may not be discharged but

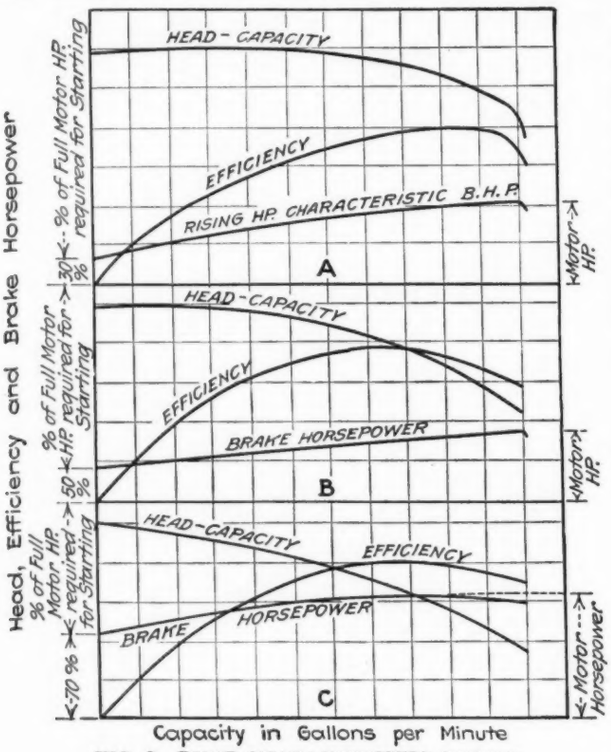


FIG. 2. PUMP CHARACTERISTIC CURVES

merely circulate around inside of the pump, still the load on the motor will be increased.

Then again, possibly to meet certain conditions, a pump will have what is known as a rising horsepower characteristic, which means that the horsepower does not drop off as the head decreases and the pump delivers more water, but increases with the discharge. With a pump having a rising horsepower characteristic as in chart *A*, Fig. 2, if there is a possibility that it will be operated against lower than rated heads, it should accordingly be connected to a motor large enough to handle the load over the complete pumping range of head without being dangerously overloaded.

Still other pumping units are used in places that are hot, damp or poorly ventilated, and to insure reliable operation the motors will be selected slightly large. Finally, the present trend in rating motors is to give them a maximum rating with very little if any overload capacity. This means that maximum rated motors, particularly for driving pumps, will have to be chosen big enough at the outset, as they would not work safely if overloaded. For all these reasons the usual practice in fitting motors to centrifugal pumps, as previously stated, is to allow 10 per cent. leeway over the horsepower that it is figured will be required.

Besides knowing the size of motor to put on a pump, it is necessary also to know something about the starting requirements of centrifugal pumps and how they affect the selection of the type of motor and also the starting apparatus to be used. Centrifugal pumps are started up quite easily and are generally considered "light starting duty for a motor." Consequently, squirrel-cage motors, and even synchronous motors that do not have much starting torque, can be used to drive centrifugal pumps, but this statement needs a little explanation. The curves of Fig. 2 are typical of the performance characteristics of three different types of centrifugal-pump runners. Chart *A* is for a standard single-stage centrifugal pump fitted with a runner having a rising horsepower characteristic. By slightly changing the runner design, this pump can be made to have a horsepower curve that is practically flat from the point of maximum efficiency on. Chart *B* is representative of the ordinary type of multistage pump with diffusion vanes, and chart *C* shows the characteristics of a single-stage pump with a so-called Francis type runner which is particularly designed so that relatively high pump rotative speeds can be employed for low heads. These curves have been reproduced to show in particular the "shutoff horsepower" of different kinds of pump runners. This is the power required to rotate the pump runner at rated speed in the pump casing when full of water but when no water is allowed to be discharged, as would be the case when the pump is started up with the valve in the discharge from the pump closed. The shutoff horsepower has been indicated as a certain percentage of the horsepower required at the highest point of the curve, which has been taken as 100 per cent.

Slip-ring or shunt-wound direct-current motors will start pumps having the characteristics shown by all three curves, and squirrel-cage motors also have been found capable of starting these pumps, although in the larger sizes and sometimes for pumps having the characteristics shown by chart *C*, squirrel-cage motors will take too much current in starting to be used. Standard synchronous motors will ordinarily start pumps having the characteristics of chart *A*, and develop the necessary torque to pull into synchronism when up to speed, but will have to have specially constructed motors to develop the 50 per cent. of rated horsepower required to pull pumps having the characteristics of chart *B* into synchronism, and cannot be used at all, except by making special arrangements to start pumps having the characteristics shown in chart *C*.

The special arrangement just mentioned is to equip a pump so it can be started up empty and then primed after being brought up to synchronous speed. What is done is to provide some means of lubricating the close clearances in the pump until it can be primed, when the water will provide the lubrication. The necessary arrangements can be made easily on single-stage pumps, but it is rather difficult to fix up the multistage type. For this reason they are seldom started up empty, although clutches are sometimes employed.

All the previous remarks apply to pumps that are started up with a closed valve in the discharge. As a

general rule this should be figured on, as otherwise starting conditions will be much worse. It is necessary only to refer to the curves again to see that where no discharge valve is provided, the motor in coming up to speed has also to come up to full horsepower and be thrown on the line at full rating instead of at a fraction of full horsepower. This is not good practice and is

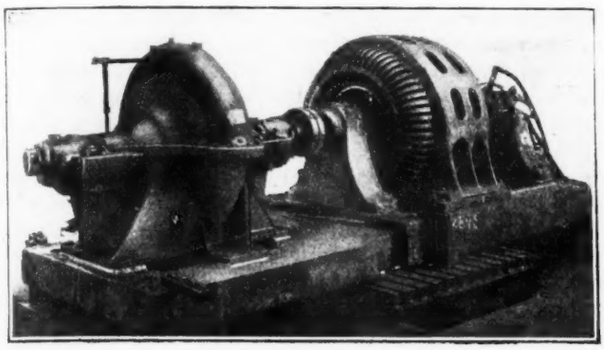


FIG. 3. MOTOR-DRIVEN SINGLE-STAGE 10500-G.P.M. CENTRIFUGAL PUMPING UNIT

bad for the motor even if undue disturbances will not be caused in the line. Instances have been known where the heavy surges of current to start squirrel-cage motors attached to centrifugal pumps without any valve in the discharge have in time loosened up the motor coils.

Having considered the power required to start and operate centrifugal pumps, brief reference will be made to the kinds of motor used for pump drive. This is a large subject in itself and will be taken up in detail in succeeding articles. Probably the motor most commonly used to drive centrifugal pumps is of the squirrel-cage induction type. This motor, on account of its simplicity and also because the starting duty of a centrifugal pump is not heavy, is used to drive the majority of small and moderate-sized pumps.

In sizes over 150 hp. and in many cases less, the slip-ring induction motor is used instead of the squirrel-cage type, because it takes less current from the line in starting. Also power companies often fix the maximum size of squirrel-cage motor they will allow to be connected to their lines. In still other cases where a system does not have much capacity, throwing a large squirrel-cage motor on the line would cause serious disturbances and possibly a voltage drop that would be enough to prevent the motors coming up to synchronous speed. These cases call for the use of slip-ring motors. This type is used sometimes when a moderate amount of speed control of the pump is required, possibly to maintain a constant pressure with a variable discharge or to maintain a constant discharge with varying heads.

Direct-current motors as well are used where speed variation is required, but for constant-speed service are not used so much as induction motors. Then, too, for moderate heads standard centrifugal pumps ordinarily run at higher than the best direct-current motor speeds. However, relatively high-speed direct-current motors are now being built that can be used as satisfactory pump drives where only direct current is available.

As a fourth kind of pump drive synchronous motors are just beginning to receive deserved attention. Many centrifugal pumps, because they offer a constant steady load, present a fine opportunity for using a large synchronous motor to keep up or correct the power factor of a power system, and by using proper care suitable synchronous motor-driven centrifugal pumps can be often selected.

Before leaving the subject of the horsepower requirements of centrifugal pumps as related to motor drive, possibly it will be well to point out a few troubles that are sometimes encountered with motors and that are traceable to the centrifugal pump. The most common difficulty, which has been mentioned previously, is operating an improperly selected pump at less than the rated head. This will overload the motor and cause it to run hot. Another trouble almost as common is pump and motor out of alignment due to improper erection. This causes vibration and hot bearings and wears out rapidly the coupling bushings. A third trouble sometimes experienced and resulting in hot motor bearings, is when the centrifugal pump develops an end thrust, causing collars on the shaft to rub on the ends of the bearings. End thrust may develop in a single-stage double-suction pump on account of one side of the runner becoming partly obstructed or an obstruction lodging in the suction passage on one side, which unbalances the runner. Unequal wear of the runner wearing rings on opposite sides of a double-suction runner or displacement of the runner slightly to one side of the center line of the casing also will cause thrust. In multistage pumps thrust is generally caused by failure or partial failure of the arrangements provided to balance the end thrust. Two pumps taking their suction from the same suction pipe or discharging into the same discharge line, if they are not properly arranged and do not have the right kind of characteristics, can cause trouble by dividing the work unequally, but this and similar questions are outside the scope of this article.

It can be safely stated that a pump should not be bought merely as a pump of a certain size without any

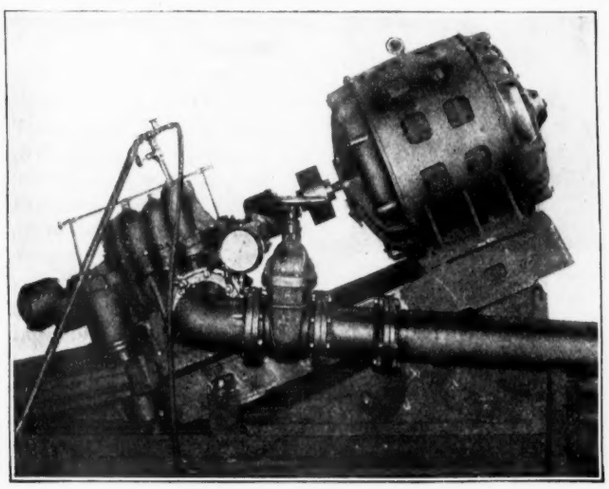


FIG. 4. MOTOR-DRIVEN MULTISTAGE 1800-G.P.M. CENTRIFUGAL PUMPING UNIT

Both motor and pump have combined radial and ball thrust bearings as the unit operates in the inclined position shown.

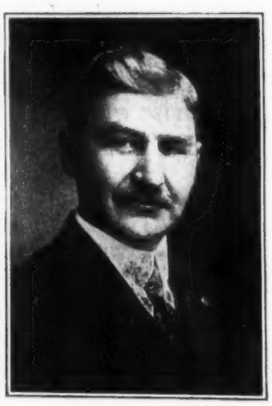
reference to the work it will have to do. In conjunction with the driving motor it should be selected to do certain definite work to the best advantage. It is therefore preferable to buy pumps that have been tested carefully and their characteristics determined, with motors of suitable size to run the pumps under all the conditions that will be met with in service. That is, a pump and the drive should be considered as a unit and selected accordingly.

Outlook for the Heavy-Oil Engine

A Discussion by Engineers Prominent in the Oil-Engine Field Covering Present Practice, Tendencies in Designs and the Commercial Prospects

ECONOMY of the Diesel engine is so much superior to that of any other type of prime mover that it is certain not only to remain in its present field but to attain wider employment. It is particularly suited for locations where coal is expensive and fuel oil cheap, although it may often be used to advantage even where coal is cheap, especially in small plants that do not operate continuously, for the reason that stand-by losses of coal-burning plants are eliminated. In Diesel engines the matter of size has little influence on the economy, and in small electric plants using oil at one dollar per barrel the cost of fuel is only about one-quarter of a cent per kilowatt-hour and in a small flour mill in which Diesels are installed, the cost of fuel per barrel of flour runs about one cent with oil at one dollar per barrel.

Diesel engines in electric plants will deliver a kilowatt-hour on three-quarters of a pound of oil, while in the best steam plants (large units) where oil is used as fuel under the boilers, the oil consumption per kilowatt-hour ranges from 1¼ to 1¾ pounds.



C. G. SPRADO

One of the most promising fields for the Diesel engine is marine propulsion, because the weight of fuel to be carried for a given voyage is only about one-third of that required for steam vessels using coal as fuel. This means an increase in cargo space of approximately twenty per cent., a much smaller engine-room crew and a form of fuel that can be much more conveniently handled and stowed than coal or, if desired, the steaming radius of the Diesel ship can be made much greater than is possible with a steam-driven ship without carrying an excessive weight of fuel.

The weight of coal for a steamship, either turbine or reciprocating-engine driven, is practically three times that of fuel required for a Diesel engine of the same power, and even if oil were burned under the boilers on the steam-driven ship, the weight of fuel would be more than double that required for the Diesel-engine ship.

Diesel-driven ships of any size should be fitted with two engines and twin screws as is customary with steam-driven ships, but it is especially necessary for the larger Diesel ships on account of the limitation of the size of engines which it has been found feasible to construct up to this time.

Owing to the high pressures used and the high temperatures developed, the Diesel engine has some limitations as to size and up to the present time has not been built much above 3000 hp., and its development above this power will probably be rather slow, so that at present it can be considered only for plants of moderate size or for large plants where it is desirable, on account of flexibility, to have several units.

While the Diesel engine has unequaled economy, its reputation has suffered in some instances from being used under unsuitable conditions, but more especially by unskillful handling. Overenthusiastic advocates of the Diesel engine have injured its reputation by leading purchasers to believe that the machine was "fool-proof" and required no operating skill; but as a matter of fact, in return for its very high economy the Diesel engine demands a certain amount of attention (such as grinding valves, etc.) at the right time, and there are instances where absolutely duplicate installations have either been highly successful or practical failures, dependent entirely on the skill of the operating crew.

The Diesel engine is practically a "maximum rated" machine, for its power is limited by the volume of air compressed in the main cylinders, as the amount of oxygen present determines the quantity of oil that can be given perfect combustion. It can readily be seen that on this account Diesel engines are limited to small overload capacity and that for comparatively short periods, but they will operate with relatively high economy on lighter than maximum loads.

Like all moderate-speed internal-combustion engines, the Diesel has a relatively high first cost per brake horsepower, and in order to offset this there has been a tendency among builders to over-rate their engines both as to capacity and speed; while this may do no harm on fluctuating loads, it is sure to give unsatisfactory operating results on continuous heavy loads such as marine work, pumping, flour mills, etc., owing to overheating, carbon from incomplete combustion, etc.

In brief, it may be said that the Diesel engine has the limitations of all internal-combustion engines, which, however, are not serious and are now well understood; and because of its superior economy and ability to operate on any kind of liquid fuel, it may be confidently predicted that it will find a rapidly widening field and will continue to be used so long as fuel oil is obtainable at any reasonable cost.

C. G. SPRADO,
Engineer in Charge of Gas and Oil Engines,
Allis-Chalmers Manufacturing Co.
Milwaukee, Wis.

DR. DIESEL secured his first patent in 1893, and the first successful engine was put in operation in 1897 in a match factory in Germany. During the duration of the original Diesel patents the use of this invention was mostly limited to one licensee in each of the principal countries, and the late Adolphus Busch, of St. Louis, Mo., induced by the late Colonel Meier, obtained the sole right for this country. When the original patents had expired, approximately 50,000 hp. in Diesels were in operation in this country, and as by this time their economic superiority had been proved, a large number of manufacturers here, and still more abroad, took up the manufacture of this engine.

It has often been asked why it is that the European countries have developed this engine on a much larger scale than this country has done it, in spite of the fact that oil here is so much cheaper than in Europe. Some of the reasons are the following: Firstly, coal is much cheaper in this country than in Europe; secondly, the steam engine is much cheaper here than in Europe, but the Diesel engine is not and will never be, as it is an engine of high-class material and skilled workmanship; thirdly, in America the question of first cost is more important than it is in Europe where economic operation and the greatest possible economic production are the leading and cogent features in industry. However, our easy attitude in this direction has been changed more or less through this war, and we also will in the future be compelled to watch the economic side if we want to compete in the world market, particularly at the present rate of labor.

A great deal of resourceful study and work of this kind is bound to set in. Actual figures of operation of plants in Texas, Arizona and other Southern States where Diesel engines were substituted for steam plants showed the following saving: A barrel of flour was produced at 1½ to 1¾ cents for fuel oil, compared with 8 to 10 cents and more for steam; and water pumped at from 7 to 9 gal. of fuel oil per 100 water hp. against 50 to 60 gal. for steam plants. Similar remarkable results have been obtained in ice and electric-power plants and with marine Diesels. The quoted examples apply, of course, in the same measure to other parts of the country. Wherever we have today an oil-fired boiler, by putting in a Diesel engine only one-third to one fifth of the fuel will be required. This fact is at the same time an answer to the fuel-oil supply of the future, since we can on this basis more than triple the capacity of our prime movers before we reach again the demand of fuel under present conditions.

At the present time we are most interested in the question as to whether the Diesel engine is still in its experimental stage and if there is enough experience available to guarantee success to the manufacturer when he enters this new field. The latter certainly must be answered in the affirmative. The next question is, which type is the one to be preferred? The writer claims that this can today be answered definitely on the basis of failures or final success in actual operation. It is known which types have failed and which have met with indisputable success and why. Of course there still remain questions to be solved, but as a whole it can be said that competent Diesel engineers have settled down to certain generally recognized standards which must be followed if a successful Diesel engine is expected. This applies to design, construction and operation.

A few items as to the design, which have become recognized elements, may be enumerated. The trunk piston has given a very satisfactory service up to about 16 in. in diameter; for larger sizes most of the leading manufacturers have adopted the crosshead type. With about this size, or starting perhaps with 20 in. in diameter, water cooling of the piston is required. The elements that demand the most attention as to design are a rigid and heavy baseplate, with well-supported bearings, and, as to design and material, it is the piston, cylinder liner and cylinder head.

In the writer's opinion the future development of the oil engine in this country will see, up to 200 or 300 hp., at the most, the more cheaply constructed hot-bulb engine (not Diesel) prevailing on the market; from there up to 2000 or 3000 hp. the single-acting four-cycle engine, and from 2000 hp. upward the double-acting two-cycle type.

The single-acting two-cycle stationary engine in larger units has met so far with little success except perhaps under particular conditions, where the full rated capacity has never been called upon or in the most during a very short interval at the time of peak load. Judging by single-acting two-cycle engines which the writer has watched in operation, the bearing troubles —that is, the continuous one-sided pressure—seem to be the most serious. At the present time on the test stand of one of our largest companies of the world a single-acting marine Diesel of about 2600 hp. is being submitted to the severest test in order to study these various questions, and we engineers must congratulate any company that is willing to do such pioneer work and we may hope that this engine will show up in actual sea operation better than other European types of this class have done. It has been reported that Sulzer Bros., of Switzerland, have recently had great success with this type of engine, but it still remains to be seen how they will stand up in continuous operation.

H. SCHRECK

Another novelty in this line is the solid-injection engine, which type is still too new for one to express any definite opinion one way or the other. It only may be said that the tests, so far carried on with it, entitle one to expect a great future for it, which is all the more to be hoped, as it simplifies the Diesel and makes it a cheaper engine.

It might be of interest to mention the limit that has been reached so far as to size. Sulzer Bros. have built stationary two-cycle engines of about 4000 hp. each, with cylinders of 29.92-in. bore; the "Bullaren," built in Sweden, has two six-cylinder four-cycle engines of 29⅛-in. bore; the "Glenapp," built in England, has two eight-cylinder four-cycle engines of 29½-in. bore; and the Engine Works of Nuremberg, Germany, have probably by this time finished and delivered their three-cylinder double-acting two-cycle engine of 31½-in. bore.

From these figures it would seem that about 30-in. cylinder bore is the limit to which one can go safely. Going to a still larger cylinder bore increases the difficulty of transmitting sufficiently the excessive heat through the cylinder walls, and with a larger size we are going into the experimental region of the Diesel engine. Schneider & Cie., of France, have been running for some time on the test stand a single-cylinder two-cycle unit of 39⅜-in. bore which is developing 1200 hp. in this one cylinder. As far as the construction of larger engines in this country is concerned, it can be stated that only two companies have under construction four-cycle engines whose cylinders are of 28 and 30-in. bore, respectively, which is about 250 to 300 hp. per cylinder.

H. SCHRECK,
Chief Engineer Diesel Engine Department,
Whittelsey & Whittelsey, Naval Architects.
New York City.

THE first internal-combustion engine was designed to use gas for fuel, and 95 per cent. of the engines of today are gas engines trying to run successfully on liquid fuel more or less imperfectly gasified by atomization and heat.

So used to gas engines are both the builders and the ultimate users that a change from this type of prime mover to a type using fuel which will not gasify by induction seems such a radical innovation and a herculean task that builders of automotive engines hesitate to start such a departure, yet practically every concern building large gas engines is getting into the heavy-oil type.

But the advantages of engines using fuel or crude oil as found in nature over that type of engine which must have volatile hydrocarbon fuels to work successfully, are so great, even if the price of fuels were not taken into consideration, that in the writer's opinion self-igniting constant-compression heavy-oil engines even for automotive purposes will become standard and a universally used type much sooner than the most optimistic expect. While large fuel-oil engines have been in successful operation for years, some running continuously for six months at a time without a shutdown, builders of automobile engines, whose output exceeds the output of the manufacturers of all other prime movers, are still making the original gas engine with its low, inefficient compression and complicated ignition system, until now the price of volatile hydrocarbons has increased 600 per cent. On account of the variable disassociation characteristics of the volatile fuels now obtained by intensive distillation, explosion pressures in gas engines often reach twice the maximum pressure obtained in the cylinder of a high-compression fuel-oil engine, so the question of weight and strength is in a sense automatically solved by the light-weight variable-compression engines withstanding these excessive pressures.

C. E. SARGENT

As efficiency increases with compression in any internal-combustion engine and as the compression of gas engines which compress a combustible mixture is limited by the critical pressure of preignition, the heavy-oil engine compressing pure air from five to eight times higher, naturally delivers a horsepower on a smaller number of heat units per hour.

The present standard automotive gas engine, of which millions are in operation every day of the year on account of a limited compression must have an intricate, complex (and often defective) ignition system to start the inflammation, while heavy-oil engines with high compression automatically provide the heat for ignition.

While the ordinary gas engine at full load is about two-thirds as efficient as the heavy-oil type, yet the method of controlling the speed and load by varying the quantities of the constant mixture induced, is as inefficient as throttling a steam engine to reduce the mean effective pressure.

Constant-compression engines using a liquid fuel the quantity of which varies with the load will eventually supersede variable-compression gas engines with complicated gas-making attachments if thermal efficiency is taken into consideration and simplicity and reliability are to be desired.

The company with which the writer is connected is building one- to six-cylinder heavy-oil engines from ten to one thousand horsepower and expects eventually to furnish heavy-oil engines for trucks, tractors and automobiles which will fit in standard chassis, as well as larger engines for all purposes of the most exacting conditions, including reversing marine and power-plant units.

C. E. SARGENT,
Chief Engineer, Midwest Engine Co.
Indianapolis, Ind.

AT THE present time probably all reputable manufacturers of stationary oil engines have sufficient orders on their books to keep them busy for six months or a year to come. This great volume of business at the present time is to some extent due to the fact that many large users of oil engines for one reason or another did not make the usual enlargements to their equipment during the period of the war, and now that labor is more plentiful the increase in their business has necessitated this action. The outlook for future oil-engine business is encouraging and may be still more so as prices of raw materials decrease. As long as skilled labor demands the high rates now existing, the price of the finished oil engine cannot be much decreased.

Great developments and improvements have been effected in oil engines in the last ten or fifteen years, with regard to reliability in operation and also as to economy of fuel. The guarantee of 0.9 lb. of fuel made fifteen years ago is now reduced to 0.45 or ½ lb. per b.hp. per hour, which is made by many concerns both with the hot-surface type and Diesel oil engines. While the earlier engines could burn only the lighter fuels, today the guarantees already mentioned are made when using any fuel or crude oil produced in the United States or Mexico. Many oil engines have operated continuously day and night for six and eight months at full load, which is a sure proof of their reliability.

In the larger sizes, say from 500 to 1000 hp., where a highly skilled attendant can be in charge, the full Diesel type of engine has many advantages and probably will be favorably considered by prospective purchasers. In sizes, say, from 25 to 500 hp., the hot-surface type, with its lower range of pressures and greater simplicity of construction, will find favor. For land installations, except where local conditions such as water and relative cost of fuels favor the oil engine, plants of over 1000 hp. may find competition of the steam turbine not inconsiderable.

The oil engine, on account of its high first cost, is essentially a prime mover which shows to the greatest advantage when operating with a maximum horsepower-hour output per year. It is also supreme in positions where only a bad quality of water, unsuitable for boiler use, is available, and its economy is most prominently set forth where all fuels are at a high cost. For land purposes the horizontal type, on account of its greater accessibility for inspection and repairs, is most favored. The vertical type, for marine installations or for places where floor space is restricted and where sufficient headroom is also available, is employed.

There is a tendency to develop "solid fuel" injection with some Diesel types, thus eliminating the high-pressure air and three-stage air compressor. In the hot-surface type the tendency of improvement which the company that the writer is connected with has followed is the production of an oil engine having a high efficiency, equal to that of the Diesel, but with comparatively low compression, and also, of course, with "solid fuel" injection.

A. H. GOLDINGHAM,
Mechanical Engineer, De La Vergne Machine Co.
New York City.

Reversing Field Connections of Compound Generator

BY B. A. BRIGGS

When the field coils of a generator are connected so that their magnetomotive force opposes that of the residual magnetism in the polepieces, the machine cannot build up its voltage. Not infrequently the statement is made that the remedy for this condition is to "cross the field connections." In a shunt machine this can generally be easily done, and as far as the shunt winding in a compound machine is concerned the foregoing is always true. But in the compound generator, to keep the series winding the same polarity as the shunt, the leads of the former must also be crossed if this is possible. However, if the machine is of 100-kw. capacity or above, it not infrequently happens that the series-field leads are heavy copper bars brought to terminals, as shown in Fig. 1, which makes it impossible to cross these leads.

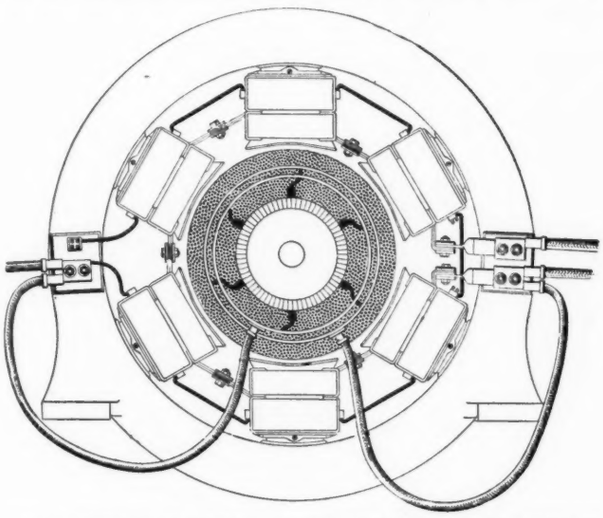


FIG. 1. DIRECT-CURRENT GENERATOR SHOWING NORMAL POSITION OF THE BRUSHES

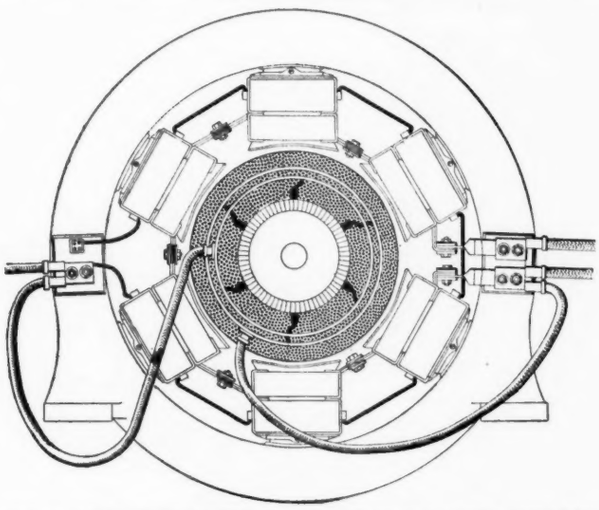


FIG. 2. DIRECT-CURRENT GENERATOR BRUSHES SHIFTED TO REVERSE THE POLARITY

If it is necessary to cross the field connections for the machine to build up, the shunt connections can be crossed and the generator will come up to voltage, but if the field windings are in opposition when the load is thrown on, the voltage will decrease very rapidly as the load increases, owing to the demagnetizing effects of the series-field winding.

It may be possible to cross the armature connection instead of the field. If this can be done, the machine will come up to voltage and the field windings will have the correct polarity. But at the best this generally results in a bad arrangement of the leads around the brush gear, and in many cases the armature leads cannot be crossed.

The best solution of the problem is obtained by shifting the brushes from one neutral position to the next, which means that the brushes will be shifted 90 deg. on a four-pole machine, 60 deg. on a six-pole machine, etc. A comparison of Figs. 1 and 2 will make clear this idea. The brushes in Fig. 2 have been shifted clockwise around the commutator 60 deg. from that in Fig. 1. This will reverse the current through the field windings of Fig. 2 and is the equivalent of crossing the leads of both field windings in Fig. 1.

In a plant where the generator had been moved from one location to another, difficulty was experienced in getting the machine into service. An electrician was called in and found that the generator would come up to full voltage, but that when the load was thrown on the voltage dropped about fifty volts, indicating that the shunt and series-field windings were in opposition. The first solution suggested was to cross the series-winding leads. However, this could not be done as they were made of copper bars, as in the figures, and it was not until after considerable effort that the proper solution was discovered. This was to shift the brushes from one neutral to the next, which left the machine so that it could not build up. Then by crossing the shunt-field leads the machine came up to voltage with the field winding the correct polarity and was put into service without any further trouble.

The cause of the difficulty was that the machine had been dismantled to move it and when reassembled the brushes had been shifted around the commutator the space between two adjacent sets of brushes. When this was done, the machine would not build up; then, to remedy this, the shunt-field winding was crossed, which allowed the generator to come up to voltage but left the field windings in opposition. No doubt the trouble would have been rectified by crossing the series-field lead, if this could have been done, without the true cause even being discovered, but in this case the heavy copper-bar terminals prevented applying this remedy.

The water removed from crude oil by electrical dehydration is of considerable value, for much of it is of such character as to be available for boiler feed.

Operation at Holtwood

RECORD KEEPING FORMS *and* FOLLOW-UPS

By

Charles H. Bromley

Describes some of the principal record forms used at Holtwood. It is likely that many engineers will find suggestions of value in this description of the Holtwood record forms.

The large hydro-electric station of the Pennsylvania Water and Power Co. is at Holtwood, on the Susquehanna River about twenty-five miles from Lancaster, Penn., and about forty miles in an air line from Baltimore, Md. The power house and dam are of concrete construction, the dam being 2370 ft. long and 53 ft. high, with a base width of 65 ft. The capacity of the station is 118,500 hp. in eight units, five of 13,500 hp. each and three of 17,000 hp. each. Electricity is generated at 11,000 volts and transmitted at 70,000 volts. For further construction details see article by the author, "Power" May 13, 1913.

COPE of the Holtwood Records—The purpose of record keeping at Holtwood is to have before the chief operator a complete record of operation; of cleaning and inspection of all equipment, hydraulic and electrical; of maintenance, that is, repairs done and to be done; of troubles and interruptions; of the estimated and actual river flow, together with conditions of tied-in steam reserve stations and of load demands to facilitate load dispatching. While the reports, charts and follow-up forms are numerous, their use is made convenient by having the much-used forms—as for example, the electrical cleaning progress sheet and the electrical and hydraulic maintenance progress charts—mounted in glass-front cases on the wall. All reports, records and charts are bound in loose-leaf books and kept in metal filing cabinets in the chief operator's office, where they are often referred to.

The Station Log Sheet—The daily report or station log, Fig. 1, will, upon studying it a little, be seen to be thorough yet not burdened with unnecessary items. The main electrical-connections diagrams on the log sheet, one diagram for each watch, is, so far as the writer knows, original with Holtwood. The operator going off watch indicates in red ink on the diagram what oil switches and other connections are closed or open. In the event of disturbances or interruptions the inked-in connections have shown themselves of value in settling disputes, which at times arise.

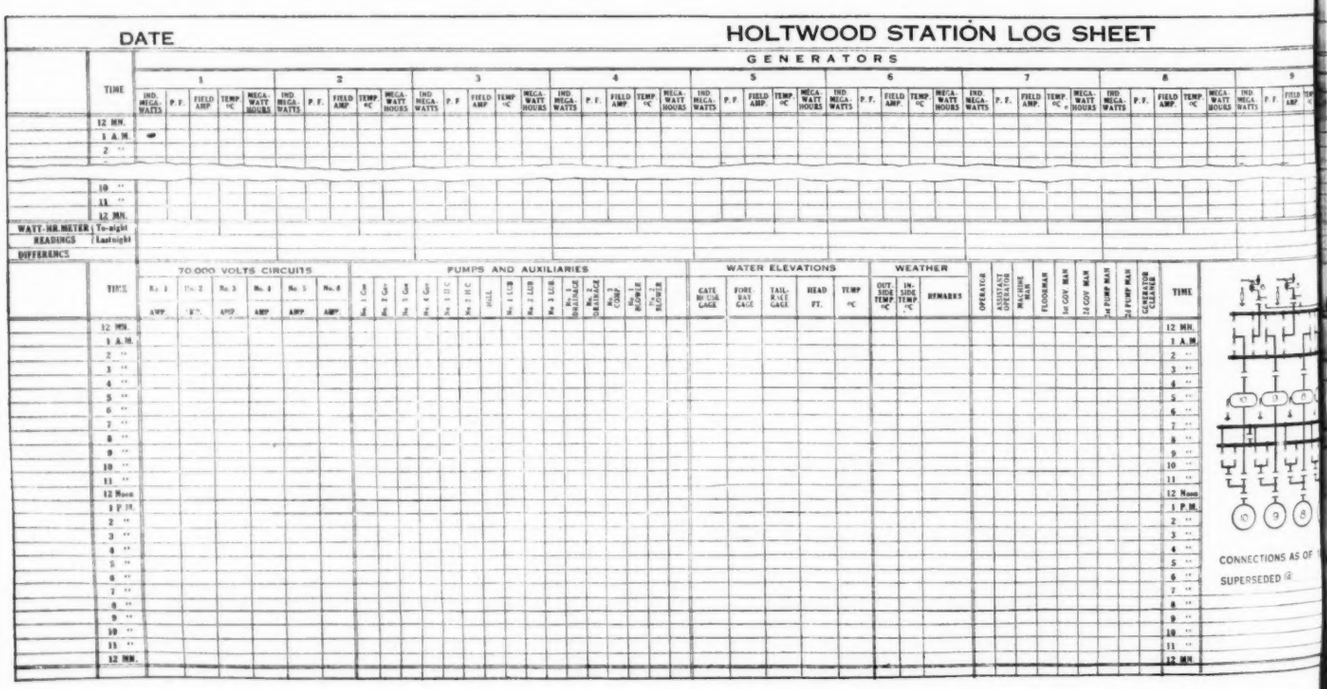
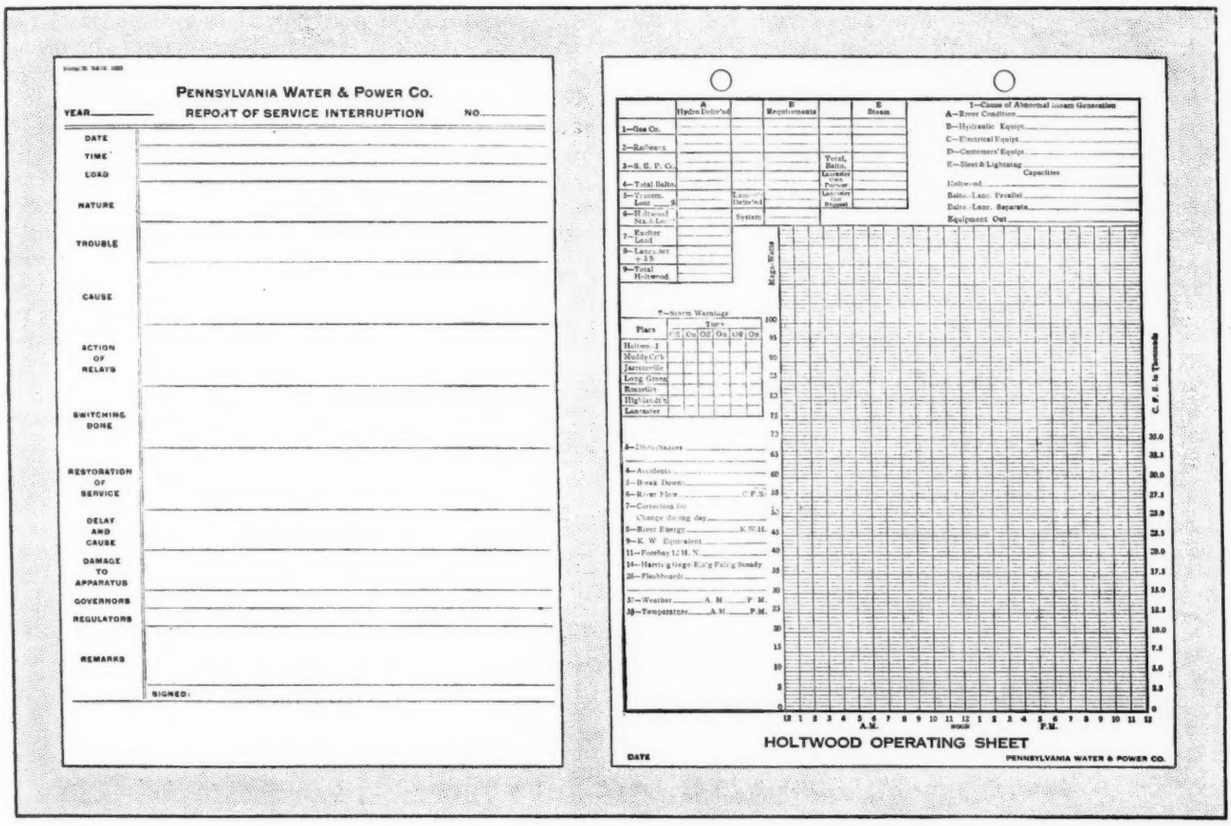


FIG. 1. FACSIMILE OF THE DAILY LOG SHEET USED IN THE HOLTWOOD



PENNSYLVANIA WATER & POWER CO.

YEAR_____ REPORT OF SERVICE INTERRUPTION NO._____

DATE
TIME
LOAD
NATURE
TROUBLE
CAUSE
ACTION OF RELAYS
SWITCHING DONE
RESTORATION OF SERVICE
DELAY AND CAUSE
DAMAGE TO APPARATUS
GOVERNORS
REGULATORS
REMARKS

SIGNED:

FIG. 2. SERVICE INTERRUPTION REPORT

HOLTWOOD OPERATING SHEET

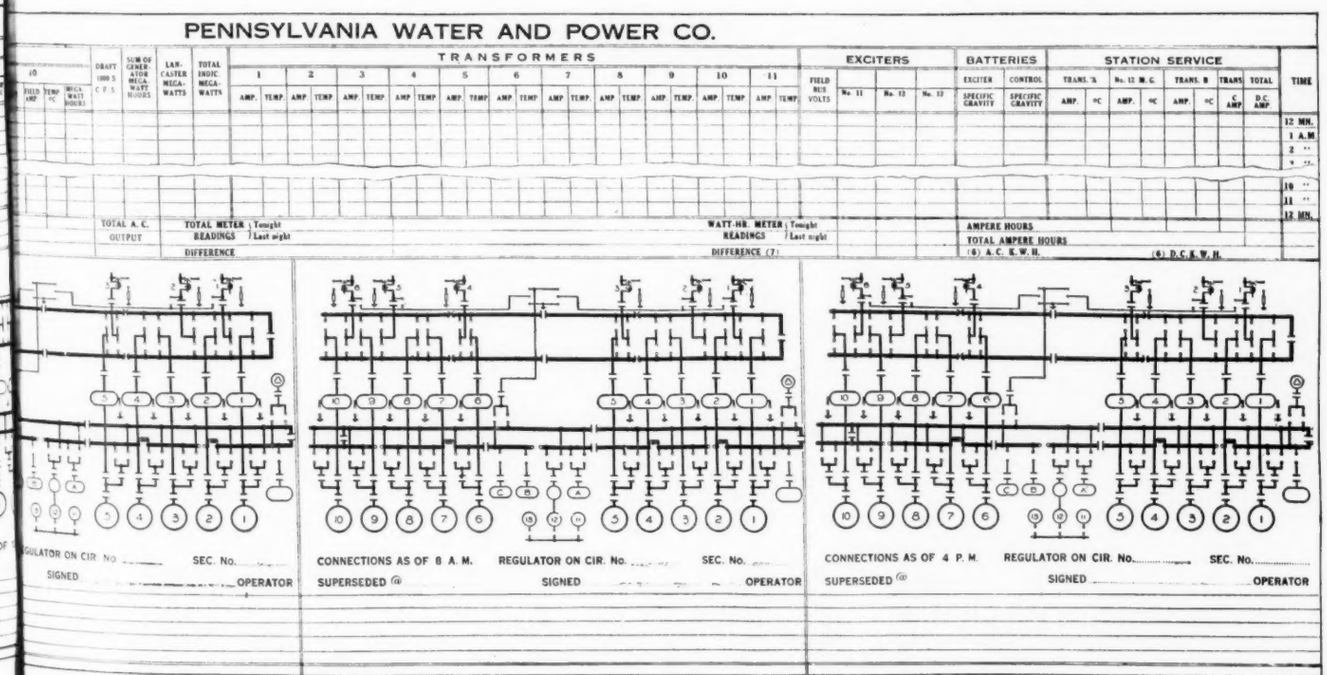
DATE

PENNSYLVANIA WATER & POWER CO.

FIG. 3. DETACHABLE END OF THE DAILY LOG SHEET

Notice that the megawatts instead of watts are entered on the sheet. This is done to save writing in a great number of ciphers each day. The switchboard operators and machinemen will tell you how they appreciate the use of "megawatts."

The right-hand end of the log sheet, shown in Fig. 3, is detachable and punched for insertion in the filebook. The load curve and the curve of the power-house draft, as computed hourly from the turbine-efficiency charts by the operator, are plotted on the sectioned part of the sheet; the time that each main unit is in service is indicated by lines at the top of the sectioned portion drawn against hours. The electrical transmission system covers a wide area, and much of it is in a hilly



PENNSYLVANIA WATER AND POWER CO.

TRANSFORMERS 1 2 3 4 5 6 7 8 9 10 11 (AMP. TEMP.)

EXCITERS: FIELD BUS VOLTS; No. 11; No. 12; No. 13

BATTERIES: EXCITER SPECIFIC GRAVITY; CONTROL SPECIFIC GRAVITY

STATION SERVICE: TRANS. A; No. 12 M.G.; TRANS. B; TRANS. C AMP; TOTAL D.C. AMP

DRAFT (1000 C.F.M.); SUM OF GENERATOR MEGAWATT HOURS; LANCASTER MEGAWATTS; TOTAL INDIC. MEGAWATTS

TIME: 12 MN. 1 A.M. 2 " 9 " 10 " 11 " 12 MN.

TOTAL A.C. OUTPUT

TOTAL METER READINGS | Tonight | Last night

DIFFERENCE

WATT-HR. METER READINGS | Tonight | Last night

DIFFERENCE (7)

AMPERE HOURS

TOTAL AMPERE HOURS

(6) A.C. K.W.H. (6) D.C. K.W.H.

REGULATOR ON CIR. No. _____ SEC. No. _____

SIGNED _____ OPERATOR

CONNECTIONS AS OF 8 A.M. REGULATOR ON CIR. No. _____ SEC. No. _____

SUPERSEDED @ SIGNED _____ OPERATOR

CONNECTIONS AS OF 4 P.M. REGULATOR ON CIR. No. _____ SEC. No. _____

SUPERSEDED @ SIGNED _____ OPERATOR

STATION. SEE FIG. 3 FOR THE DETACHABLE END OF THE SHEET

country where electrical storms sometimes become violent. Whether at Holtwood or at the various substations, steam stations or along the transmission right-of-way, sleet and storm warnings are immediately reported to Holtwood.

Notice that the river energy, that is, the number of kilowatt hours available from the river flow, also the leakage through the flashboards, and overflow, are recorded. The "K.W. Equivalent" item calls for the number of kilowatt-hours produced per cubic foot of water.

DATE_____ PENNSYLVANIA WATER AND POWER COMPANY Holtwood, Pa.
Watthour Meter Reading Sheet

Gens.	1 A.M.		2		3		4		5		6		7		8		Gens.
	Read	Diff.	Read	Diff	Read	Diff	Read	Diff	Read	Diff	Read	Diff	Read	Diff	Reading	Diff	
1																	1
2																	2
3																	3
4																	4
5																	5
6																	6
7																	7
8																	8

FIG. 4. MIMEOGRAPHED FORMS USED BY THE CREW IN TAKING READINGS

The forms, Figs. 4 and 5, were developed by the switchboard operators to facilitate taking readings of the many meters. These forms are mimeographed and used by the men when taking meter readings, which later are transferred to the station log. There is many a plant that might advantageously follow Holtwood's practice in the use of these mimeographed sheets instead of furnishing the men with scrap paper.

Service-Interruption Reports—Fig. 2 shows the service-interruption report form. These are in three colors: Blue for troubles originating at Holtwood station; buff for the transmission lines and substations; white when the cause originates with the customer. Going hand in hand with these reports and attached thereto for transmittal to the chief operator is the service-interruption diagram, Fig. 8, which needs no explanation. The trouble report used in the station is shown in Fig. 7. Notice that the trouble is reported in detail so that the information may be available for transfer to the Machinery Record, Fig. 9.

DATE_____ PENNSYLVANIA WATER AND POWER COMPANY OUTPUT DATA SHEET Holtwood, Pa.

Generators	1	2	3	4	5	6	7	8	Prev. Read.
Tonight									
Last Night									
Difference									

	Tot. Net	Exc. 11	Exc. 12	Exc. 12
Tonight				No.
Last Night				1
Difference				2

Sta. Serv.	Amp.	K.W.H.	Exc. 11
A. Transf.			D.C. Gen
B. Transf.			Exc. 12
C. Transf.			Tot. D.C.
Total			D.C. Sta.
D.C.			Ex'tion

Mega Watt			Hours	
Time	West-port	P.St.	Lanc.	
1 A.M				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
1 P.M				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

Actual Highlandt'n Load Data

Gas Company
Railways
S.E.P.Co.
Tot. Baltimore
Hydro at Sub-Sta.
Westport Steam Gen.
Pratt St. Steam Gen.
Total Steam Gen.
Weather _____ A.M._____ P.M.
Tempt._____A.M._____ P.M.

Ac'tn. H'wood

A.C. Generation
D.C. Generation
Total Holtwood
A.C. Power
D.C. Power
Total Power
Excitation _____%
Exc. No. 12
A.M. Ind. Peak
P.M. Ind. Peak
Average K.W.H.
Load Factor
Highest Tail Race
Lowest Tail Race

Estimated Highlandtown Load Data

Gas Company
Railways
S.E.P.Co.
Total Baltimore
Hydro Energy at Sub-Sta.
Trans. Loss _____%
Holtwood Sta. & Local

Excitation Load _____%
Lanc. Hydro Energy 5%
Total Holtwood
Westport Steam Gen.
Pratt St. Steam Gen.
Total Steam Gen.

FIG. 5. MIMEOGRAPHED DATA SHEET USED BY CREW IN TAKING READINGS

Dictaphone—Another very interesting feature of the semipermanent operating records at Holtwood is the use of a dictaphone. Dictaphones have been used at the power house and at the principal substation in Baltimore since 1914 as a result of a suggestion made by one of the company's operators. With the aid of a dictaphone, the giving and receiving of messages, operating instructions, etc., are made more systematic. When a phone rings, before removing the receiver the operator simply says the time; then after removing the receiver he gives the name of the station and of himself, repeats then the message to the person who gave it and gives his answer to the question. The person on the other end of the line repeats the answer and the operator confirms the correctness of the other man's understanding by the word "Right." With one operation the conversation is recorded with no guesswork or uncertain recollection of what was said, as the operator can place the reproducer in repeating position and have the time and conversation repeated to himself.

Repeating of all messages over the phone, including orders given verbally to assistants, etc., was Holtwood practice even before the use of the dictaphone, so that no additional time is required for the recording of the conversations on both ends. However, at present a further improvement in this respect is contemplated by the use of a vacuum tube in the receiving apparatus that would energize a loud speaking telephone connected directly to the dictaphone instrument.

The following is from a typical dictaphone record of conversation between the operator at Holtwood and the substation at Highlandtown; record started 4:09 p. m., Mar. 31, finished 4:58 p. m., Apr. 1.

"Mar. 31: 5:10 p.m. Holtwood; Harvey: Willie, our capacity will probably be reduced to 65,000 over night due to work on the restoring mechanism of No. 5 unit

governor. That's right. [The man at Highlandtown has repeated the sentence.] We are not sure you see ——No. I'll let you know if we want stand-by; we ought to be able to go through O. K. without it. I'll call you. All right.

"5:50 p. m. Holtwood; Harvey: Our capacity is now 75,000. No. 5 unit is ready for service. That's right.

"Apr. 1: 12:12 a.m. Holtwood; Shaub: Westport's maximum capacity is 20,500—10,000 available on six boilers, otherwise the same.

To the Patrol Chief: 4:46 p. m. Holtwood; Harvey: Parker at tower 360. Right. No. 1 is clear and ready for service as far as your work is concerned. All right. I'll report you clear on No. 1 circuit, time 4:47. Right."

When a record cylinder is filled, it is removed from

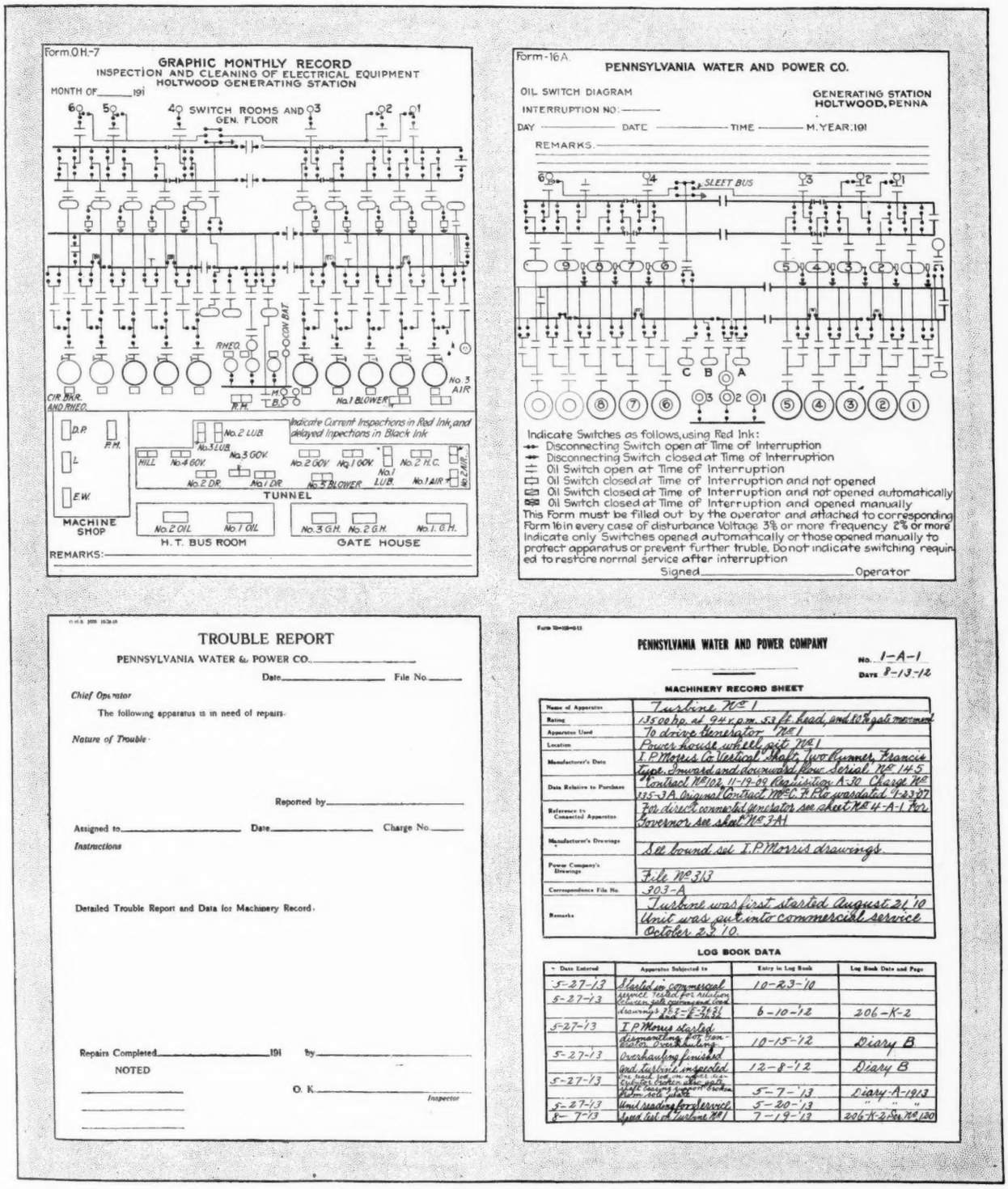

Form O.H.-7
GRAPHIC MONTHLY RECORD
INSPECTION AND CLEANING OF ELECTRICAL EQUIPMENT
HOLTWOOD GENERATING STATION
MONTH OF _____ 191
SWITCH ROOMS AND GEN. FLOOR
MACHINE SHOP
TUNNEL
H. T. BUS ROOM
GATE HOUSE
REMARKS:
Indicate Current Inspections in Red Ink, and delayed Inspections in Black Ink
Form-16A
PENNSYLVANIA WATER AND POWER CO.
OIL SWITCH DIAGRAM
GENERATING STATION HOLTWOOD, PENNA
INTERRUPTION NO:
DAY DATE TIME M. YEAR: 191
REMARKS
SLEET BUS
Indicate Switches as follows, using Red Ink:
Disconnecting Switch open at Time of Interruption
Disconnecting Switch closed at Time of Interruption
Oil Switch open at Time of Interruption
Oil Switch closed at Time of Interruption and not opened
Oil Switch closed at Time of Interruption and not opened automatically
Oil Switch closed at Time of Interruption and opened manually
This Form must be filled out by the operator and attached to corresponding Form 16 in every case of disturbance Voltage 3% or more frequency 2% or more
Indicate only Switches opened automatically or those opened manually to protect apparatus or prevent further truble. Do not indicate switching required to restore normal service after interruption
Signed _____ Operator

FIG. 6 (TOP). GRAPHIC MONTHLY RECORD OF INSPECTION AND CLEANING OF ELECTRICAL EQUIPMENT

FIG. 8 (TOP). GRAPHIC REPORT OF ELECTRICAL INTERRUPTIONS; NOTE THE SYMBOLS USED

TROUBLE REPORT
PENNSYLVANIA WATER & POWER CO.
Date _____ File No. _____
Chief Operator
The following apparatus is in need of repairs.
Nature of Trouble
Reported by _____
Assigned to _____ Date _____ Charge No. _____
Instructions
Detailed Trouble Report and Data for Machinery Record.
Repairs Completed _____ 191 by _____
NOTED
O. K. _____
Inspector
PENNSYLVANIA WATER AND POWER COMPANY
No. 1-A-1
Date 8-13-12
MACHINERY RECORD SHEET
Name of Apparatus: Turbine No 1
Rating: 13500 hp. at 94 r.p.m. 52 ft. head, and 80% gate movement
Apparatus Used: To drive Generator No 1
Location: Power house wheel pit No 1
Manufacturer's Data: I. P. Morris Co Vertical Shaft Two Runner Francis Type. Inward and downward flow. Serial No 1415
Data Relative to Purchase: Contract No 102, 11-19-09 Requisition A-30 Charge No 335-3 A. Original Contract No C. P. Co. was dated 9-23-07
Reference to Connected Apparatus: For direct connected generator see sheet No 1-A-1 For Governor see sheet No 3-A1
Manufacturer's Drawings: See bound set I. P. Morris drawings
Power Company's Drawings: File No 313
Correspondence File No: 303-A
Remarks: Turbine was first started August 21 '10 Unit was put into commercial service October 23 '10.
LOG BOOK DATA
Date Entered | Apparatus Subjected to | Entry in Log Book | Log Book Date and Page
5-27-'13 | Started in commercial service | 10-23-'10 |
5-27-'13 | Governor tested for relation between gate movement and load | 6-10-'12 | 206-K-2
5-27-'13 | I. P. Morris started dismantling for Francis Runner Overhaul | 10-15-'12 | Diary B
5-27-'13 | Overhauling finished and Turbine inspected | 12-8-'12 | Diary B
5-27-'13 | Unit reading for service | 5-7-'13 | Diary A-1913
5-27-'13 | Unit ready for service | 5-20-'13 | " " "
8-7-'13 | Speed test of Turbine No 1 | 7-19-'13 | 206-K-2 Sh No 120

FIG. 7 (BOTTOM). FACSIMILE OF THE TROUBLE REPORT

FIG. 9 (BOTTOM). THE MACHINERY RECORD FORM

the mandrel and a new one is put in its place. If there is anything of particular interest recorded on a cylinder, it is marked "Important" and is saved for ten days; if, at the expiration of this time there is no controversy about any of the conversation on the record, it is shaved.

Machinery Record Sheet—One of the forms that most impressed the writer is the machinery record sheet, Fig. 9. This particular sheet is typical of the record

PENNSYLVANIA WATER AND POWER COMPANY

PACKING DATA

APPARATUS	STUFFING BOXES LOCATION	DIMENSIONS		PACKING SIZE	QUANTITY	KIND	WHEN PACKED DATE	LIFE	DATE	LIFE	DATE	LIFE	DATE	LIFE	DATE	LIFE	DATE	LIFE
No. 1 MAIN UNIT OPERATING CYLINDER	LOW PRESSURE	Diam. Piston Rod																
		Diam. Stuffing Box																
		Depth Stuffing Box																
	HIGH PRESSURE	Diam. Piston Rod																
		Diam. Stuffing Box	6½"	¾" □														
		Depth " "	4½"															
	PISTON HEAD	Diam. Cylinder	21"		4 Rings													
		Diam. Piston Hd. Recess	19½"	¾" □	ff	Hemp.												
		Width of Recess	3"		lb. Oz.													
No. 2 MAIN UNIT OPERATING CYLINDER	LOW PRESSURE	Diam. Piston Rod	5½"		6 Rings													
		Diam. Stuffing Box	6½"	¾" □														
		Depth " "	4½"															
	HIGH PRESSURE	Diam. Piston Rod	5½"		6 Rings													
		Diam. Stuffing Box	6½"	¾" □														
		Depth " "	4½"															
	PISTON HEAD	Diam. Cylinder	21"		4 Rings													
		Diam. Piston Hd. Recess	19½"	¾" □	ff	Hemp.												
		Width of Recess	3		lb. oz.													
No. 3 MAIN UNIT OPERATING CYLINDER	LOW PRESSURE	Diam. Piston Rod	5½"		6 Rings													
		Diam Stuffing Box	6½"	¾" □														
		Depth " "	4½"															
	HIGH PRESSURE	Diam. Piston Rod	5½"		6 Rings													
		Diam. Stuffing Box	6½"	¾" □														
		Depth " "	4½"															
	PISTON HEAD	Diam. Cylinder	21"		4 Rings													
		" Piston Hd. Recess	19½"	¾" □	ff	Hemp.												
		Width of Recess	3"		lb. oz.													

	APPARATUS	ASSIGNED TO	MAIN UNITS No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10	EXCITERS No.11	No.12
GOVERNOR CONTROL SYSTEM	Governor Sump Tanks	Floorman												
	Governor Sump Tanks Cooling Coils	"												
	" Valves and Piping Flushing	"												
	" Control Pumps	Mc Neill												
	" Control Pump Check Valves	F												
	" Accumulator Tanks	"												
	" Accumulator Tank Check Valves	"												
	" Reserve Accumulator Tank	"												
	" Complete	Q												
	" Regulating Valves	"												
	" Gear Drive	Q												
	" Restoring Mechanism	F												
HAND CONTROL SYSTEM	Hand Control Sump Tanks													
	Hand Control Valves and Piping Flushing													
	" " Pumps													
	" " Pump Check Valves													
	" " Accumulator Tank													
	" " Balance Pipe Valves													
MISCELLANEOUS	Water Rheostat													
	Pressure Gages													
	Stairways and Railings													
	Window Operating Mechanism													
	Machine Shop Equipment													
	No.1 Trans. Cooling Tank													
	No.2 " " "													
	Cleaning Forbay													
CRANES	Generator Room Crane													
	Gen Room Crane Cables Lubricated													
	Gate House Crane													
	Gate House Crane Cable Lubricated													

KEY: Yearly, 6 Months, 4 ", 3 "

Completed regular Inspections to be indicated by writing Date in Space opposite Apparatus

Supersedes Drwg. No. 151-A-2296

151-C-5553	STARTED-FINISHED	PENNSYLVANIA WATER AND POWER CO.	HOLTWOOD POWER DEVELOPMENT	No. SCALE	151-C-5553
Started by F.G.	12-10-17			Progress Chart of Hydraulic Inspection Year 191____	
Finished by F.G.	12-11-17				
Traced by W.G.	12-24-17				
Checked T.G.S.-H.	1-3-18				
Approved	1-3-18				

FIG. 10 (TOP). PACKING DATA SHEET USED AT HOLTWOOD

A large quantity and wide variety of packing is used. This sheet serves not only as a record of packing sizes and number of rings required for the different stuffing-boxes, but more important, gives the life of each kind of packing used.

FIG. 11 (BOTTOM). PROGRESS CHART OF HYDRAULIC INSPECTION

The completed regular inspections are indicated by writing the date in the space opposite the name of the apparatus.

As a rule the records from the power house and substation referring to all abnormal operating events or disturbances are transcribed at the office. They furnish a valuable adjunct in the analysis of all disturbances, showing not only to what extent the operating attendants displayed precision and good judgment in handling any particular trouble, but also paving the way sometimes for further improvements.

At Holtwood cleaning of equipment, hydraulic and electrical, is assigned to particular men, and such assignments are listed and posted on the station wall in a Rand visible index, thus arguments among the men as to who kept of all machinery worth recording. The value of the form is obvious.

1918 WORK SCHEDULE

JOB	CHARGE	DAYS	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
BALLANTYNE:														
No.9 Trans. Reactance Coil Repairs	R-3031	9	○○○											
No.5 Circuit Lightning Arresters	R-3031	12	○○○											
No.6 Trans. Gr. Stack, cut to Std. Size	R-3031		○											
No.5 Circuit Oil Sw. Control remove Obstruction in Conduit	R-3031	3	○											
11 K.V. Station Service Disc. Sw. Install Lock	C-81	6	○	○										
11 K.V. Bus Install New Type Filler Pieces	R-3031	8	○○											
Trans. Transil Oil Pumps, permanent Lighting	C-88	2	○											
No.1, 2, 3, 4, and 6 Cir. Lightning Arrester overhauling	R-3031	15		○○○○○○										
No. 2 and 3 Cir. C.T. Changing Oil	R-3031	4		○○										
H.T. Bus Room Barriers Fence on Top of-	R-3031	7		○○○										
No. 6 and 8 Gen. Field Pole Insulating Rings	R-3031			○○										
Booster Exciter-Change Control Location	R-3031	6		○○										
Grounding Jumpers Make-up 3 additional Sets	R-3031	3		○										
Oil Gages New Type- install on No. 3 and 5 Transformers	R-3031	6		○	○									
Relays-Removing Trans. H.T. Series	R-3031	6		○	○									
Arc Extinguisher relays Overhaul	C-85	30		○○	○○○○									
Hold off Signs L. and H.T. Buses	R-3031	5		○○										
No. 3 Generator Temperature Indicator Install.	C-81	1		○○										
BENCHBOARD IMPROVEMENTS														
No. 3 Gen. Panel, Lamp resistance form Splices on Board	C-47	3	○											
No. 5 Gen. Panel make and install Control Form	"	6	○○											
No. 8 Gen. Panel, put Annunciator Cable in shape	"	2	○											
Control distribution Bus relocate	"	7	○○○											
Telltale Relay Install Bell	"	3	○											
Station Service Panels rewire	"	12		○○○○										
New Control Bus install.	"	12				○○○○								
Regulator, A.C. Feed Sw. Change Type and Location on Board	"	6					○○							
Regulator run New D.C. Feed from Booster Feed	"													
ONEILL														
Dowelling No. 4 and 5 Gen. Frames	C-69	15	○○○○○											
Stop Oil Leaks in No. 8 Unit Gov. Gear Case	R-3032	3		○										
Repairs to No. 8 Unit Gov. 7" Stop Valve	R-3032	6		○○										
Install Shutter and Steps on No. 1 Blower	"	3		○										
Remodelling Blower Chain Guard	"	9			○○○									
Repairs to No. 6 and 7 Unit Main Shaft Gov. drive Gears	"	6			○○									
Repairs to No. 11 Exc. Lower Guide Bearing	"	3		○										
Supporting Power House Office Roof	R-302	3			○									
Repairs to No. 8 Unit Head Gates	"	3		○○										
Repairs to No. 8 Turbine Guide Bearing	"	6				○○								
Rebabbiting No. 2 and 3 Gov. Pump Motor Bearings	R-3031	6					○	○						
Improved Oiling Device for Hill Pump	R-3032	4	○		○									
No. 7 Unit 14" Penstock Valve Stem	"	2			○									
No. 11 and 13 Exc. Magneto-Tachometers	"	6				○○								
Re-aligning No. 1 Drainage Pump Drive Shaft	"	6					○○							
Re-adjusting Head Gate Brakes	"	6					○○							
KEATING														
Corrosion Inspection of Gov. System	R-3037	2	○											
Improvements to Ground Stack Railings	R-3031	6	○	○										
" " No. 2 H.C. Pump Suction Piping	R-3032	2		○										
" " No. 1 H.C. " " "	R-3032	2			○									
Increase No. 4 Transf. Cooling Water Discharge Piping	C-79	3			○									
Improvements to Tunnel 3" Forebay Water Line	R-3032	6			○○									
Install Syphon-Circulating Line between No. 2 and 1 Gov. Sump Tank	R-3032	2					○							
Install Oil Filling Lines to all Gov. Drive Shaft Bearings	C-77	21				○○○	○○○○							
Repairs to No. 1 Gov. Sump Tank Cooling Coils	R-3032	3						○						
Repairs to No. 3 Gov. Sump Tank Cooling Coils	R-3032	3				○								
Install Filter Water Line to control Battery Room	R-3032	2						○						
Install Pressure Gages in Tunnel	R-3032	2						○						

UNIT NO. _____

INSPECTION OF			MATERIAL		DATE INSTALLED		DATE / INSPECTOR			DATE / INSPECTOR			DATE / INSPECTOR			DATE / INSPECTOR		
PART			PIN	EYE BUSHING	PIN	EYE BUSHING	LOST MOTION	REMARKS	REPLACEM'T OR REPAIRS	LOST MOTION	REMARKS	REPLACEM'T OR REPAIRS	LOST MOTION	REMARKS	REPLACEM'T OR REPAIRS	LOST MOTION	REMARKS	REPLACEM'T OR REPAIR
GROSS HEAD PIN																		
CONNECTING ROD PIN																		
REACH ROD PINS	UPPER	N.E.																
		N.W.																
		S.E.																
		S.W.																
	LOWER	N.E.																
		N.W.																
		S.E.																
		S.W.																
UNK PINS	UPPER	O.R.																
		VANE																
	LOWER	O.R.																
		VANE																
HEADGATES																		
Condition of Gates																		
Condition of Lifting Mechanism																		
CASTINGS																		
Condition of Castings																		
Broken Bolts and Loose Nuts																		
GREASE PIPING																		
Condition of Grease Piping																		
Loose Hangers																		
Are all Pins and Bearings getting grease?																		
Upper Fulcrum Pins charged with							LB.		GREASE	LB.		GREASE	LB.		GREASE	LB.		GREASE
Lower Fulcrum Pins charged with							LB.		GREASE	LB.		GREASE	LB.		GREASE	LB.		GREASE

FIG. 12 (TOP). HYDRAULIC YEARLY WORK SCHEDULE. FIG. 13 (BOTTOM). HYDRAULIC INSPECTION FORM

will do this and do that never happen; instead, equipment is properly cleaned. Definite assignment of caring for apparatus furnishes quite an incentive to individual members of the force to make a creditable showing within the sphere of their responsibility no matter how small these duties may be.

Especial attention is given electrical apparatus. A cleaning progress chart, or list on which every piece of electrical apparatus is designated, together with dates and names of men assigned to clean particular apparatus, is inclosed in a glass-front case on the wall (see the headpiece). As each apparatus is periodically cleaned, the date is entered and the name of the apparatus checked off. Fig. 6 shows the graphic monthly

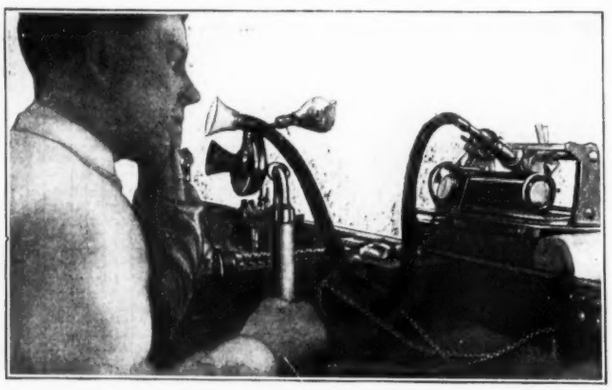


FIG. 14. SWITCHBOARD OPERATOR GIVING INSTRUCTION TO SUBSTATION BY 'PHONE
His conversation is recorded on the dictaphone. Note the watch hanging on the front (left) of the dictaphone.

record of inspection and cleaning of electrical equipment. Notice that current inspections are indicated in red ink and delayed inspections in black ink.

Progress Chart of Hydraulic Inspection—Fig. 11 shows one of the progress charts of inspection of hydraulic machinery. The key to the various rectangles is given on the chart. Thus some machinery is to be inspected annually, others every six months, some every four and others every three months.

As each called-for inspection is made, the date is written in the corresponding rectangle.

The Yearly Work Schedule—Of all the forms used at Holtwood, the writer believes that the yearly work schedule holds first place in point of value as related to maintenance and operation. This schedule chart is shown in Fig. 12; notice that it applies to the whole station—to electrical and hydraulic equipment.

When the job called for is done, the corresponding circle is inked in in red; if half done, half the circle is inked in.

Delray Station To Be Revamped

Plans have been perfected by the Detroit Edison Co. for the installation of a new 30,000-kw. unit in plant No. 2 at Delray. To receive it, an extension will be made to the turbine room and a new switchhouse will be built. Work on the foundations has started already, and it is thought the unit will be ready for service some time next winter. At the present writing plant No. 1 can carry a maximum load of 40,000 to 44,000 kw. and in plant No. 2 the ultimate capacity is 62,000 kw., made up from four machines, three having a nominal rating of 14,000 kw. each and the fourth, 15,000 kw. By the addition of the new unit and with more economical loading of the older machines, the Delray stations will carry handily 130,000 kilowatts.

It so happens that Delray is long in boilers, or will be when the new unit is installed, owing to its low water rate, so that instead of installing a sufficient number of boilers to carry the new unit, it will be necessary to add only two 1300-hp. Stirling boilers of the same type as the 2365-hp. boilers that have long made this plant a leader in steam generation. This is explained by the fact that the new unit will carry 20,000 kw. on the same quantity of steam required by a 14,000-kw. machine. Then by adding sufficient boiler capacity to carry 10,000 kw., the load considered normal for one of the large boilers or the two new boilers, ample provision has been made for the 30,000-kw. unit.

It is the plan to remove two of the older machines eventually, one 14,000-kw. and one 15,000-kw., to make room for another 30,000-kw. unit, and finally to substitute a third large unit for the two oldest machines remaining.

Delray revamped will be a refinement of Connors Creek practice. The new G. E. unit, rated at 30,000 kw. will generate three-phase 60-cycle 12,200-volt current, the steam conditions being 200 lb. pressure and 200 deg. of superheat, and the speed 1800 r.p.m. The generator leads will be tied solidly to the low-tension terminals of a three-phase compensator-type 12,200- to 24,400-volt transformer. This will feed through single-conductor cables carried underground to the machine switches located in the switchhouse which is being built at the north end of the Delray site. There will be no main switching done in the power house proper.

On the steam end the condenser auxiliaries will be driven by direct-current motors to insure a wide range of speed variation and convenience of operation. To effect a heat balance, the plant will be provided with an auxiliary turbine exhausting into a heater condenser. To conform with the motors, the generator will be a direct-current machine. Sturdiness and simplicity of control are the reasons assigned for the choice of direct-current apparatus.

As the energy required by the auxiliaries is not at all times proportional to the load on the main generator, there will be times when the auxiliary-power demands, if supplied entirely by the auxiliary turbine, would involve an excess of exhaust steam—more than enough to heat the condensate from the main unit. At other periods the conditions may be reversed. To meet this situation, a synchronous motor-generator set will be installed.

When the load on the main unit is light and the auxiliary apparatus requires more energy than the auxiliary turbine will supply, incidentally to heating the feed water, the deficiency will be made up from the main bus through the motor-generator set, and this source will be drawn on should the auxiliary turbine be out of commission. At times of heavy load, when in order to heat the feed water it will be necessary to generate more energy than the auxiliaries require, the surplus will be transformed to the main bus through this same motor-generator by reason of its flexibility. This arrangement should prove an advance over former practice.

There will be a rearrangement of steam piping in the station, and as at Connors Creek, direct-current motors will be used to drive the blower equipment.

Conditions in the Power Industry Abroad

By L. W. ALWYN-SCHMIDT

A digest of reports of United States consuls on the power situation in various parts of the world and the influence of the war on this important industry.

MANY months have passed since the armistice was declared, but little actual progress has been made so far in the resumption of large construction work and public enterprise. Much of the present stagnation no doubt is caused by the very unsatisfactory situation in Europe. Only the neutral countries appear to have continued work on those of their hydro-electric enterprises that were in building when the declaration of the armistice suddenly brought a change in the general situation. Building has remained active in Norway and Sweden.

Available Hydro-Electric Power in Norway, Sweden and Iceland

Commerce Reports has given the European hydro-electric situation a great deal of attention, and a recent issue contains an extensive description of the situation in the two countries. It is said in this report that the total power available in Norway for development is estimated at 15,000,000 hp., while Sweden has a total reserve of 6,000,000 hp. Norway so far has developed 1,300,000 hp., while 950,000 hp. has been developed in Sweden. Norwegian water power has obtained its largest support from the electrochemical industry which has settled in recent years in that country, attracted by the extensive hydro-electric powers that might be obtained. The total developed hydro-electric power in Norway is 0.5 hp. per person, but it is only 0.17 hp. in Sweden.

Both countries have numerous developments owned as a rule by municipalities or operated under local concessions. The war has shown that many of these plants are operated on a wasteful basis, and especially that a great number of them are working on too heavy a load, making operation unnecessarily expensive, while others have a much larger output than is actually required. To correct this situation it is now contemplated to unite all the hydro-electric enterprises in a single district for the purpose of coöperative operation. The first experiment of this kind was made in central Sweden, where 33 stations have been combined. The new company will exert a sort of controlling influence in its district by directing the power production and distribution in the most economic channels. The Swedish government also is very active in promoting power development. The water-power commission, which already had $2,200,000 at its disposal this year for the purchase and extension of existing water-power developments, has asked for authorization of an additional $268,000, and $670,000 will be required during 1920.

More specific information is now obtainable on the new development contemplated in Iceland. The work for this enterprise is in the hands of a Norwegian company financed by Norwegian and Icelandic interests. The whole system will consist of a series of plants, the largest of which will be erected on the Thorsaflod, the principal river of the island. Other stations will be located at points on the tributary rivers of the main system. The local conditions for erecting the plant appear to be excellent, and it is estimated that the Iceland consumers will get their electricity as cheaply as it is sold to consumers in Norway. The total development, which may consist of six individual but interconnected stations, will produce approximately 1,114,000 horsepower.

The Water Powers of Finland

The development of the water powers of Finland has been held back in recent years by the inability of the Russian government to provide the necessary means. Finland is very similar in its topographic appearance to the other Scandinavian countries. There are high mountains approaching the sea and many rivers with powerful falls. The new Finnish republic is now making an attempt to develop part of the existing resources either by private or by government enterprise, and plans have been drawn for a hydraulic plant yielding 118,000 hp., to be located just north of Viborg. The power will be gained from a fall of the Imatra River of 68.9 ft. The cost of the whole development is estimated to be from $18,000,000 to $24,000,000. Pre-war estimates amounted to $6,000,000 only. To secure an even flow of water it is intended to make use of the Saimaa Lake, which would permit the additional use of the Vuoksen Rapids. This would add approximately 500,000 hp. to the total possible development. The present plans of the Finnish government contemplate a linking up of all the existing minor enterprises along the Vuoksen.

The present hydro-electric activity in northern Europe, including the large project in Iceland, deserves the closest attention of the American power industry. Governmental enterprise will aid in the construction of many of the new developments, but there is plenty of room for private construction. This applies especially to Finland, in which industrial progress was held back in pre-war times by the lack of coal and capital. The new republic will now have to aid in the building up of a new national industry so as to make the country reasonably independent of foreign supplies. The first step must be to supply cheap and reliable power. Full support, therefore, will be given to foreign enterprise likely to aid in the exploitation of the power resources of the nation. American capital no doubt will be welcome and its employment will be followed by orders for American power machinery and general equipment. American capital also may come handy in the development of the power-consuming industries, such as the electrochemical industry, which appears to find a very fertile field in the Scandinavian countries. So far English capital has been most prevalent in financing these enterprises with the result that much power equipment has been ordered from English firms.

Hydro-Electric Development in Great Britain and France

Accessibility to coal has so far retarded hydro-electric development in England. With coal directly at the doors of the power houses, so to speak, there was little reason to spend large amounts of money in the erection

of costly water-power stations. The increasing cost of coal and frequent labor troubles at the mines have now directed more attention to the hydro-electric possibilities of England and Scotland. There are very few water-power sites available in the south of England. More can be found in the north, and their number grows with the crossing of the Scottish border. A survey of the most promising power sites in Scotland seems to show that between 375,000 and 650,000 hp. may be made available, and authorization is now being sought by promoters to permit the development of certain sites.

The government so far has not been very ready to grant exploitation rights of water-power sites, as the whole question of supplying England with electrical power is still under discussion. The large coal interests naturally view with disfavor any enterprise that might lead to a reduction in the coal consumption, and it is likely that at first an attempt will be made to carry out the intended linking up of the great power stations in the Midlands, which has been referred to several times in the course of these reports.

The inquiry into the hydro-electric resources of France, which has been undertaken as a result of the war, is proceeding and it is now estimated that France will have at her disposal approximately 5,000,000 hp. that may be available all the year round and another 5,000,000 hp. available during only six months of the year. Of this, 750,000 hp. was developed before the war. The French government has rapidly pushed forward all the work under way during the war and it has been possible to add 415,000 hp. during the last four years. Several other projects were begun during the last year, but have not been completed. These comprise the development of 125,000 hp. during 1919 and 225,000 hp. during 1920 and 1921. When these are completed, France will have at her disposal 1,600,000 hp. derived entirely from water power.

South American Markets for Power Material

The war has broken the dominating influence of the German electrical industry in South American markets. It is estimated that the total consumption of electrical goods in South America amounted to $22,000,000 during 1913. Of this, $10,000,000 worth was supplied by Germany, $5,400,000 by England and $4,500,000 by the United States. Since the outbreak of the war Germany has practically vanished from the market and the United States imports have grown to nearly $10,000,000. The largest of the South American markets for power material is Argentina.

Argentina, unfortunately, is somewhat handicapped in developing electrical power owing to its lack of water-power sites. The only large waterfall is the Iguassu, which is situated on the Argentina-Brazil boundary, but it is too far removed from the present centers of electrical consumption to be of real use. There are, however, hydro-electric enterprises in Tucuman and Cordoba. It is estimated that Argentina employs today about 130,000 hp. of electrical energy in industrial enterprises and the electric motor power increases at the rate of 6000 hp. annually. The largest of the central stations in Buenos Aires is under German control, and German capital also is invested to the extent of $24,000,000 in many other electrical enterprises in Argentina. A second power station in Buenos Aires is financed by Swiss-Italian interests. Most of the equipment imported by these two companies is European. The electric railroads are using principally English or German motors.

The second consumer of electrical-power material of importance in South America is Brazil. The two largest central stations, those in Rio de Janeiro and Sao Paulo, are owned by the Brazilian Traction, Light and Power Co., which is a Canadian company. The Sao Paulo central-station plant supplies power to electric motors totaling 50,000 hp. and that in Rio Janeiro to 100,000 hp. There are several good prospects for the development of water power in the state of Minas Geraes. The country is rich in large and small streams falling rapidly in the direction of the coast. At the present time little use has been made of the existing opportunities, as the principal power sources are too far removed from the distribution centers to make worth while their exploitation. The largest available sites are those of the Sete Quedas, providing for 20,000,000 hp., the Iguassu with 3,000,000 hp. and the Paulo Affonso with 1,500,000 hp. Many of the smaller rivers have been harnessed successfully, providing power for neighboring cities. industrial enterprises and mines.

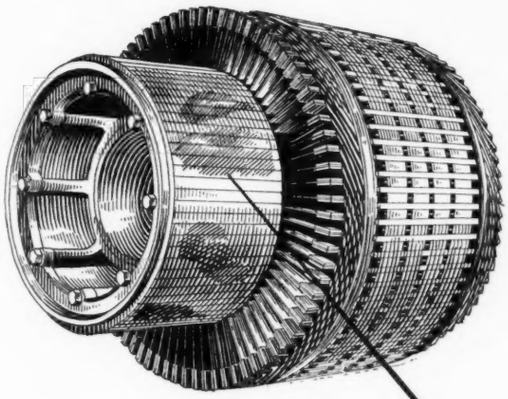
In Uruguay most of the existing central stations are owned by the government, which has a central management office in Montevideo. There is small chance for hydro-electric development and lack of coal makes necessary the use of Diesel engines for power generation.

Chile, the third market in importance for electric-power equipment in South America, has lately shown remarkable activity in the development of her hydro-electric resources. In the section from Coquimbo to Valdivia there is an abundance of water power, and the government has created a commission to study the possibility of constructing a longitudinal artery for the transmission of power through this stretch. The two large central stations in Santiago and Valparaiso are under German control.

There are several small power developments under way in South and Central America. In Nicaragua the cities of Granada and Leon are discussing the question of building electric-power stations, and an American consulting engineer has made an investigation of the available water power near Granada. In Cuba steps are being taken to rebuild the power station in Nueva Gerona on the Isle of Pines, which was destroyed during a hurricane. The Legislative Council of Guadeloupe has just granted a franchise for the control of two waterfalls that will furnish power for the operation of electric railways in the colony.

Power Development in British India

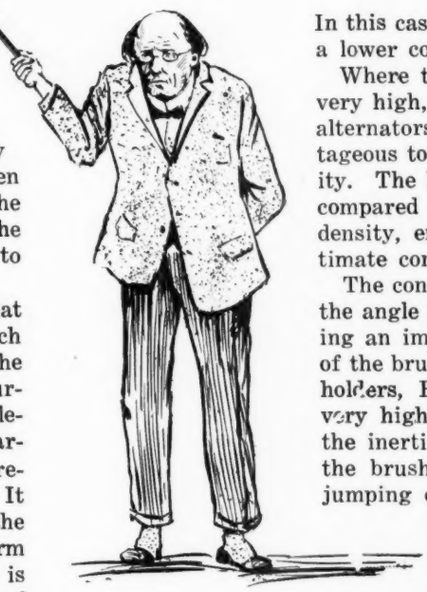
The government of India intends to have a survey made of the hydro-electric resources of British India. The British government has decided that the development of water-power sites in India cannot longer be left to private enterprise and that the government will have to undertake this work. "Owing to the great value of the natural-power resources of a country," the India Office says in a letter to the provincial governments, "it is important that each site should be developed to its full potentialities and to prevent small concerns developing the best sites for the purpose of schemes requiring limited quantities of power only, when they might have been developed into larger projects of more general public utility." The government will now make an examination of those sites already known and others will be charted so that they may be made available when required.



Flat Spots on Commutators *and* Collector Rings

By

Warren C. Kalb *



ONE of the most annoying troubles encountered in the operation of electrical machinery is the flat spot which frequently develops on both collector rings and commutators. The spots may result from a variety of conditions, and the exact cause in a given case is often difficult to ascertain. It is the purpose of this article to discuss some of the more frequent causes of this trouble and to point out how they may be overcome.

One of the most common causes for flat spots on collector rings is vibration which makes the brush break contact with the ring, producing a burned spot on the surface. This condition is especially troublesome if the vibration is of periodic character, breaking the contact of the brush repeatedly at the same spot on the ring. It may result from unequal expansion of the ring destroying its true cylindrical form as the machine warms up. This fault is most likely to occur with spoked rings of light cross-section. In some cases the trouble may be corrected by grinding the ring after it has been heated up to operating temperature. It is well, where possible, to perform this grinding operation at the full running speed of the machine, as at this speed there may be a distortion that does not exist at lower speeds. If the trouble continues after this has been done, it may be necessary to change the design of the ring, giving it a form that will not become distorted under the conditions of speed and temperature encountered in service.

Other sources of troublesome vibration are brushes too loose in the holders, insecure mounting of brush-holders, loose bearings, pound of reciprocating engines and a mechanically unbalanced rotating element. The remedy in all these cases is to correct the mechanical fault. It is wrong, as is sometimes done, to try to overcome a mechanical fault by the use of an abrasive brush.

Chattering of the brushes is a form of vibration that is frequently a source of spotting. It may be due to a loose brush-holder or too much clearance between the brush and the holder. Clearance between brush and holder, in the direction of rotation, should not exceed 0.01 in. at operating temperature, and even less clearance is desirable. Chattering may also be due to the use of a brush with too high a coefficient of friction for the peripheral speed of the ring on which it is operated. In this case it is best to select a brush with a lower coefficient of friction.

Where the rotative speed of the ring is very high, as is often the case with turbo-alternators, it is sometimes found advantageous to use a brush of low specific gravity. The lower inertia of such a brush, as compared with that of a brush of high density, enables it to be held in more intimate contact with the ring.

The construction of the brush-holder and the angle at which it is set are points having an important bearing on the tendency of the brush to chatter. Clamp-type brush-holders, Fig. 1, should never be used on very high-speed rings or commutators, as the inertia of the holder added to that of the brush is liable to cause considerable jumping even where the inequality of the contact surface is very slight. Even the weight of a rigid pressure arm, as illustrated in Fig. 2, may be sufficient to allow some chattering of the brush, which can be eliminated by the use of a light flexible blade on the under side of the pressure finger, as shown in Fig. 3.

Brushes operating in the leading or stubbing position should be inclined at a sufficient angle from the radial to insure the brush riding steadily against the leading side of the brush-holder. If the brush is set too near radial, the friction will pull it away from the leading side of the holder, tip it up on the toe and chattering will follow. An inclination of 30 deg. or more should be used when operating in this direction. Leading operation is illustrated in Fig. 2.

In trailing operation the inclination of the brush should not be so great as in leading. With too sharp an angle there is a wedging action of the brush between the ring or commutator and the trailing side of the holder, resulting in excessive friction and a sluggish action of the brush in the holder. The best angle for trailing operation will usually lie around 12 deg. to 15 deg. Fig. 3 illustrates this position.

Flat spots on rings sometimes result from hard or soft spots in the material composing the ring. This is a somewhat common fault in cast-iron rings, and spongy spots are of rather frequent occurrence in bronze rings, especially where the composition is very high in copper. Best operation on rings of this nature is generally obtained by using a brush with some polishing or even a slight abrasive action. This may result in noticeable

*Engineer, Corliss Carbon Co., Bradford, Penn.

ring wear, but if flat spots are avoided by this means, the ultimate ring life will probably be greater than would be the case where frequent turning is necessary to remove flat spots.

Current left on when the machine is standing is a less common cause of flat spots than those previously

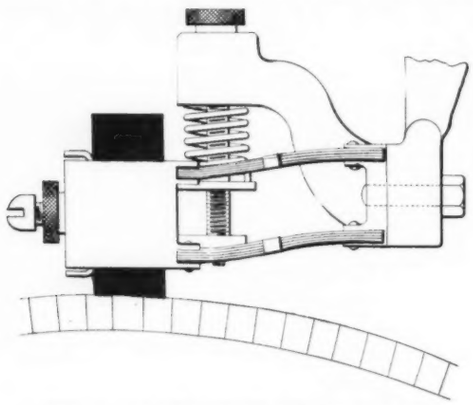


FIG. 1. CLAMP-TYPE BRUSH-HOLDER

mentioned, but one that may sometimes be found even with field rings where the current might not be thought excessive. The temperature attained at a brush contact on a stationary ring is higher than might be realized at first thought.

Surges of current due to short-circuits, sudden peak loads, hunting between machines operated in parallel or static disturbances are liable to produce small burned spots on collector rings which, if not cleaned off, may develop into spots of considerable size. The original cause in such cases may be beyond the control of the operator so that all he can do is to see that the ring is put in proper condition after the injury to its surface has taken place.

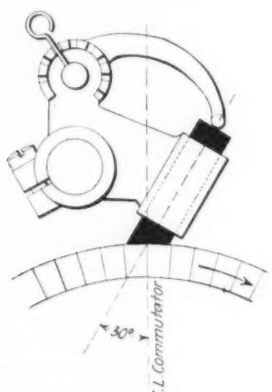


FIG. 2. BRUSH OPERATING IN LEADING POSITION

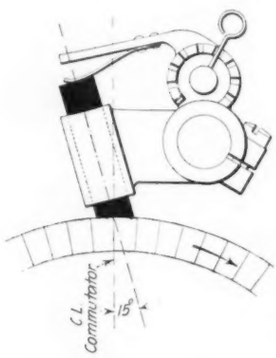


FIG. 3. BRUSH OPERATING IN TRAILING POSITION

Perhaps the most common cause for the development of flat spots on commutators is high mica. This condition results in small arcs being drawn between the brush and the edge of the commutator segments. The burning of the segments is cumulative in its action and will usually be of greater severity at certain points on the commutator than at others, due to a lack of perfect symmetry in some electrical or mechanical characteristic of the machine. If the condition is not corrected, flat spots will sooner or later develop at these points. Some of the causes of high mica are: Difference in hardness of the mica or of the commutator segments; lack of abrasiveness in brushes operated on hard, flush mica; sparking, whatever the cause may be; poorly seasoned mica. The last-named fault arises through the mica expanding and projecting beyond the copper. This may disappear after the commutator has been turned a few times due to the seasoning that takes place at operating temperatures. When this fault is found, the commutator should always be tightened before turning, as the baking out of the mica may leave the segments loose.

Sparking may result from such a variety of causes that a discussion of this point will not be undertaken in this article. Where possible, the cause of the sparking should be located and removed. Where the two remedies mentioned are not applicable or high mica recurs after they have been tried, the best procedure is to undercut the mica below the surface of the copper. The other alternative is to select a brush of sufficient abrasiveness to cut the mica down as rapidly as the copper is burned.

As is the case with collector rings, vibration is a frequent cause of flat spots on commutators. The sources

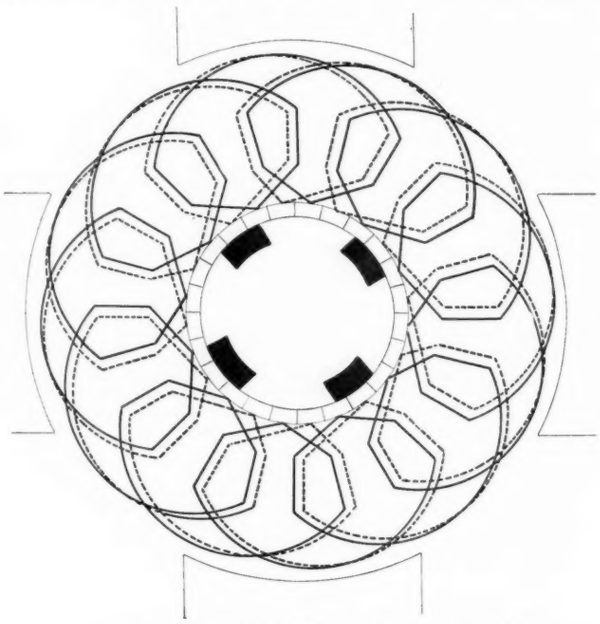


FIG. 4. DUPLEX ARMATURE WINDING

of vibration named for collector rings apply as well to commutators. A cause of flat spots peculiar to commutators is high or low bars. Where this fault is found, tighten the commutator and grind or turn it to a true cylindrical surface.

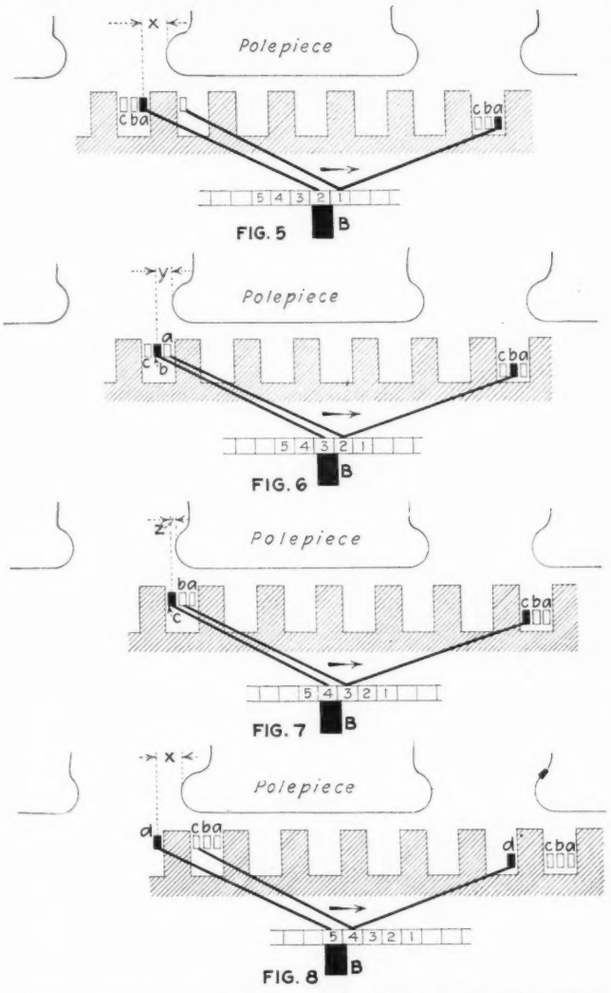
Surges of current are another source of flat spots common to commutators and collector rings. In addition to the causes named when considering collector rings, heavy surges may be thrown on the commutator of a rotary converter by putting it on the line when it is not in exact phase.

Flat spots are produced by unbalanced circuits within the armature winding, such as may occur when there is an open-circuit, a high resistance connection or a coil wholly or partly short-circuited. The remedy, of course, is the correction of the electrical fault.

Flat spots evenly spaced around a commutator are always traceable to a source having a periodic characteristic. This fact is often of assistance in locating and removing the cause. Periodic vibrations, such as may result from the pound of a reciprocating engine or

the changes in angular velocity found on a generator driven by a gas engine lacking in flywheel capacity, will be accompanied by equidistant spotting of the commutator.

Unbalanced circuits in the armature winding sometimes cause several flat spots around the commutator, due to disturbances created in parts of the winding other than that containing the electrical fault. In such cases the spots will usually be spaced at twice the distance between brush studs. Hunting of a periodic character is a source of evenly spaced flat spots, the spacing depending on the relation between the frequency of the hunting period and the speed of the machine.



FIGS. 5 TO 8. EFFECTS DURING COMMUTATION IN A WINDING HAVING THREE COILS IN A SLOT

Spotting of every second or third bar is a condition which may result where the armature has a duplex or triplex winding the parts of which are not evenly balanced. A duplex winding is shown in Fig. 4, and it can readily be seen that a condition in one portion of the winding tending to burn the commutator segments would affect only every other segment, the intermediate segments being connected to the other portion of the winding, and unaffected by the disturbing condition. This condition may arise even when the windings in themselves are perfect, owing to the fact that commutation does not take place simultaneously in the two sections of the winding. An examination of Fig. 4, in which the coils of both windings are shown in the same slot, will show that commutation in one section takes place later than in the other, the angular difference in time being the angular displacement of one segment. If the neutral or commutating field is narrow, this difference in time of commutation may be sufficient to prevent setting the brushes so that perfect commutation is secured in both windings, and burning of every other segment will result.

A similar condition arises in the case of a simplex winding where there is an insufficient number of slots in the armature, resulting in placing several coils in one slot. The condition arises, in this case, from the fact that several coils are grouped close together in one slot while the segments to which these coils are connected are evenly distributed around the commutator. Figs. 5, 6, 7 and 8 illustrate this condition. In Fig. 5 commutation in coil a is just being completed by the segment 1 passing from under the brush B. The coil at this time is at the distance x from the following pole tip.

In Fig. 6 the commutator has moved the width of one segment and coil b is just completing commutation. It will be noted that its distance y from the pole tip is less than x, Fig. 5. Similarly, in Fig. 7 commutation is seen to be completed in coil c when it is a still smaller distance z from the pole tip. Coil d in the following slot, Fig. 8, completes commutation at a distance x from the pole tip, the same as coil a. It is evident that when the brushes are so set as to give perfect commutation in coil a, there is likely to be some sparking from coil b and commutation may be so poor in coil c as to cause serious burning of the segments to which it is connected. This condition would result in the spotting of every third bar of the commutator.

To avoid the foregoing difficulty there should be not less than $3\frac{1}{2}$ slots in the space between poles. This allows a wide enough commutating zone for all the coils to commutate properly. Inasmuch as the space between poles is usually about 30 per cent. of the pole pitch, there should be not less than 12 armature slots per pole. In large machines less than 14 are seldom used.

Fallacy of Haphazard Records

BY C. C. RAITT

While there is no doubt that the records of the operation of central-station equipment can play a large part in increasing the efficiency of the plant, it is also true that records that are not accurately kept are not only useless, but may be the cause of much wasted time and effort. There is no meter that will run on indefinitely and give accurate results without periodic checking, and this is especially true of the flow meters available at the present time. Flow meters have not yet reached a stage where they can be considered sturdy.

The conditions under which they are expected to operate are anything but desirable for a delicate mechanism. There is invariably a quantity of fine coal dust in the air around a boiler room, and there is sure to be considerable vibration in the building. Therefore, if there is to be an accurate record of steam flow, someone must make frequent inspection of the meters and keep them clean and carefully adjusted.

In many cases where flow meters have been installed and the readings used for various calculations month after month, it has been found later that the meter had gotten out of adjustment and the readings were all wrong. No doubt there are instances where it is im-

possible to get a check on the flow meters and know whether they are working properly. When this is true, it is doubtful if the meters are a wise investment. However, in most cases, the capacity of the turbines or the boilers metered, together with the readings of other meters working in conjunction, should give a sufficient check on the readings of a meter.

At this point it would be well to explain just what is meant by checking a meter by the capacity of the equipment metered. It certainly does not mean that an estimate of steam flow, based on the capacity of the equipment metered, is to be given precedence over the readings of the meter and used whenever meter readings do not look satisfactory. But it does mean that whenever the meter readings do not agree with the estimate, it is time to hunt the trouble.

It should be hunted first in the meter, and if the meter is proved to be correct the reading should hold and the trouble should be hunted in the metered equipment. There is always a tendency to assume that the operation is normal and the meter wrong because it is so easy to estimate what the reading should have been and let it go at that. But whenever this is done, the purpose for which the meters were installed is defeated. A meter reading should be considered right until it is proved wrong.

In determining the pounds of coal burned in the plant, a number of difficulties arise. Where the coal burned is not of uniform size, it is difficult to obtain the weight by measuring volume. Even though it may be bought in uniform size or crushed in the station yard, there is still the danger of ice causing lumps to form which interfere with the measurements. It is best to weigh all the coal burned if possible.

Here, again, there is an opportunity for errors unless the weights are automatically recorded. It is only human to make mistakes and to be negligent where there is no check on a man's work. Therefore, to trust an employee to put down the weights without any way of knowing whether he is doing it properly or not is to invite trouble.

If it is true that the automatic mechanisms we use need care and attention, it is even more true that the human element in our records must be watched. And so it is not enough to provide means for weighing all coal burned, but some method—automatic if possible—should be used to make sure that all coal is accurately weighed.

Oil and Fuel Troubles in a Diesel Engine

By D. L. Fagnan

Poor lubrication of pistons, accompanied by excessive wear on piston rings and liners, developed in a Diesel engine. Examination showed that the crank-case oil was fairly good, but that the pistons were lubricated by an old-style force-feed lubricator. It was therefore advised that a new-style lubricator be purchased and installed, as this is timed to inject the oil in synchronism with the piston movement. That is, the oil is injected at the dead-center position of the piston at the beginning of the power stroke, so that it acts to seal the piston rings and lubricate the liner at a time when the piston is doing the most work and lubrication is most needed.

Naturally, oil delivered by the old-style lubricator to the four openings in the cylinder liners sometimes is injected at the proper time; but as other pistons may have passed the openings, any oil injected at such time does no work and is of no benefit. Instead, it helps to form carbon in the cylinder. To obtain greater benefit, the piston should be in position to receive the lubricant on its outer circumference, directly between the third and fourth rings, while it is practically at a standstill. This is the dead-center position, and so the timed lubricator gives the most efficient service on Diesel engines. A set of gears attached to the layshaft is used for timing. From 15 to 20 drops of oil per piston per minute is average practice on engines up to 225 hp. at 164 r.p.m. Above this speed proportionately more oil should be used, 30 drops per minute for larger engines being about the maximum.

By means of a bent wire it was found that the suction check on the main fuel tank was badly adjusted, and this adjustment was remedied to prevent silt, sand and such rubbish from being picked up and carried to the auxiliary fuel tank. Considerable grit had been sucked up and no doubt had caused the fuel nozzles to cut badly. They had to be reground practically every two weeks, whereas once a month should be sufficient.

All piston rings on the engine were removed, all valves, fuel nozzles and seats ground in, and new fuel-cam noses put on to replace those that were worn. The gears were checked for correct timing, and the cylinder walls were smoothed up by scraping and polishing with emery cloth. The oil in the crank case was renewed, the bearings keyed up all around, the piston pins polished, all jackets and heads washed out with a hose and the water passages examined for scale. After assembling, the engine was started, and the indicator was applied to determine the compression in each cylinder. This was found to be excellent, and no further trouble from excessive wear occurred, while the fuel consumption was notably decreased. Part of the success in providing good lubrication on this engine was due to the change of oil.

Areas of Segments of Boiler Heads

Extreme simplicity and compactness characterize the chart on the opposite page, which is intended to be used for finding the area of a boiler-head segment to be stayed, according to the latest revision of the A. S. M. E. Code. The chart was compiled by C. H. Baker, mechanical engineer, Public Service Electric Co., N. J.

The method of applying the chart may be explained most easily by an example. Suppose that a boiler 90 in. in diameter has a head $\frac{11}{16}$ in. thick and is to carry a pressure of 200 lb. gage, and let it be required to find the area of segment to be stayed, assuming that the height H of the segment is 23.9 in.

Starting from the point indicating 200 lb., on the horizontal line at the middle of the chart, proceed vertically to the curve and then horizontally to the right to the diagonal representing a head thickness of $\frac{11}{16}$ in. From this point drop vertically to the middle horizontal line, which will be cut at a point corresponding to a value of 3.9, indicating that d is 3.9 inches.

From the value 3.9 continue vertically downward to the inclined line denoting a boiler diameter of 90 in. and from that point turn horizontally to the left. As H is 23.9 in. and the value of d was found to be 3.9 in., $H - d = 23.9 - 3.9 = 20$ in. Consequently, proceed horizontally to the curve marked 20 and then vertically to the lower edge of the chart, where a value of 855 will be indiated. Then the area of the segment is 855 square inches.

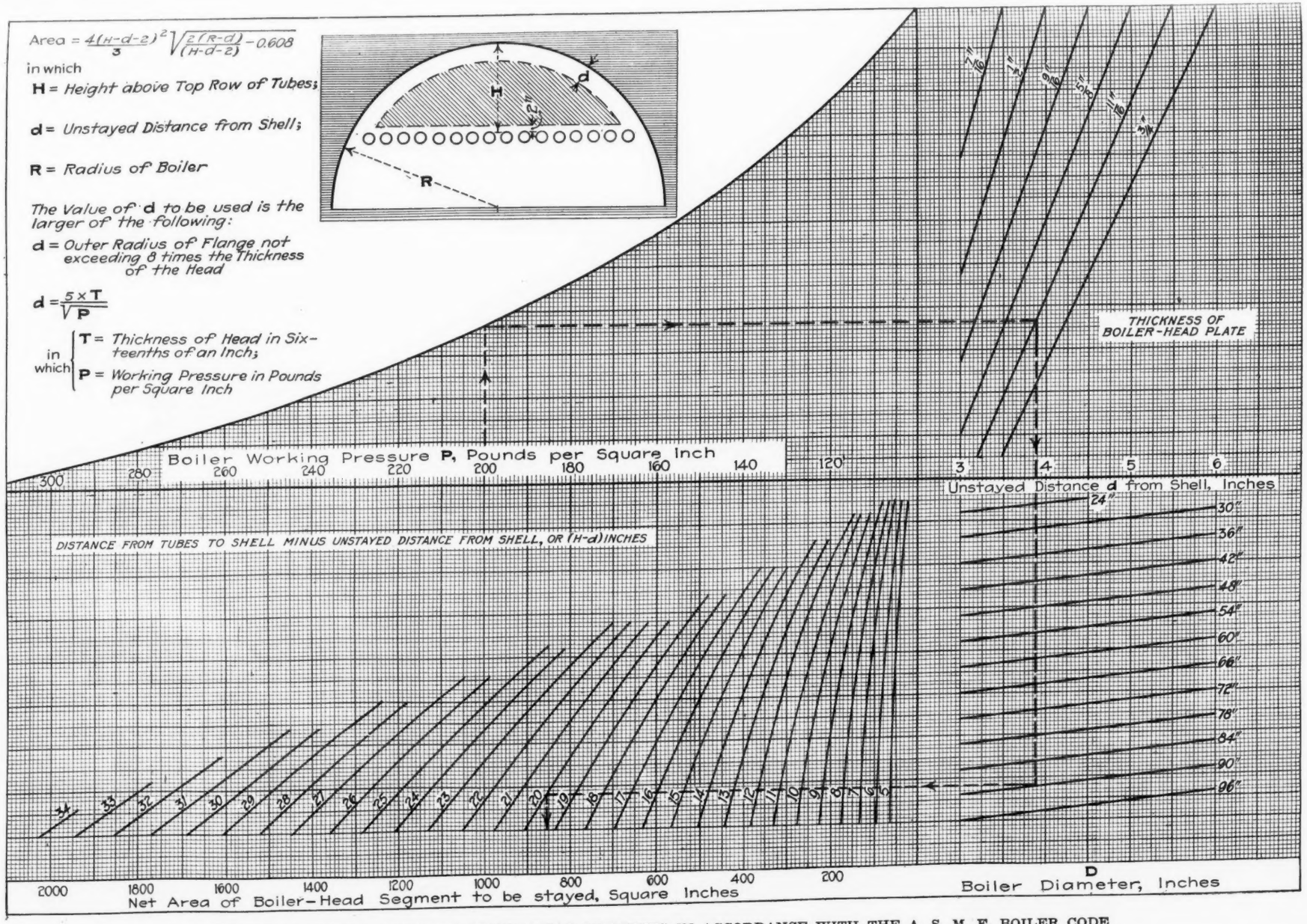
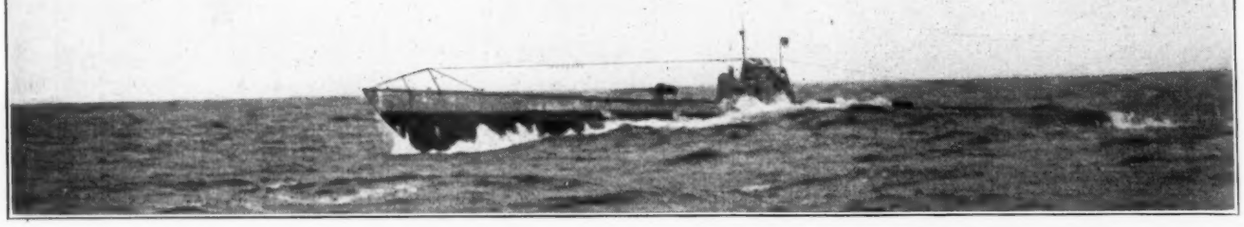

Area = $\frac{4(H-d-2)^2}{3}\sqrt{\frac{2(R-d)}{(H-d-2)}-0.608}$
in which
H = Height above Top Row of Tubes;
d = Unstayed Distance from Shell;
R = Radius of Boiler
The Value of d to be used is the larger of the following:
d = Outer Radius of Flange not exceeding 8 times the Thickness of the Head
$d=\frac{5\times T}{\sqrt{P}}$
in which T = Thickness of Head in Sixteenths of an Inch; P = Working Pressure in Pounds per Square Inch
H
d
2"
R
THICKNESS OF BOILER-HEAD PLATE
Boiler Working Pressure P, Pounds per Square Inch
300 280 260 240 220 200 180 160 140 120
Unstayed Distance d from Shell, Inches
3 4 5 6
DISTANCE FROM TUBES TO SHELL MINUS UNSTAYED DISTANCE FROM SHELL, OR (H-d) INCHES
24" 30" 36" 42" 48" 54" 60" 66" 72" 78" 84" 90" 96"
34 33 32 31 30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5
2000 1800 1600 1400 1200 1000 800 600 400 200
Net Area of Boiler-Head Segment to be stayed, Square Inches
D
Boiler Diameter, Inches

CHART FOR FINDING AREAS OF BOILER-HEAD SEGMENTS IN ACCORDANCE WITH THE A. S. M. E. BOILER CODE

Below Deck on a U-Boat

By Warren O. Rogers

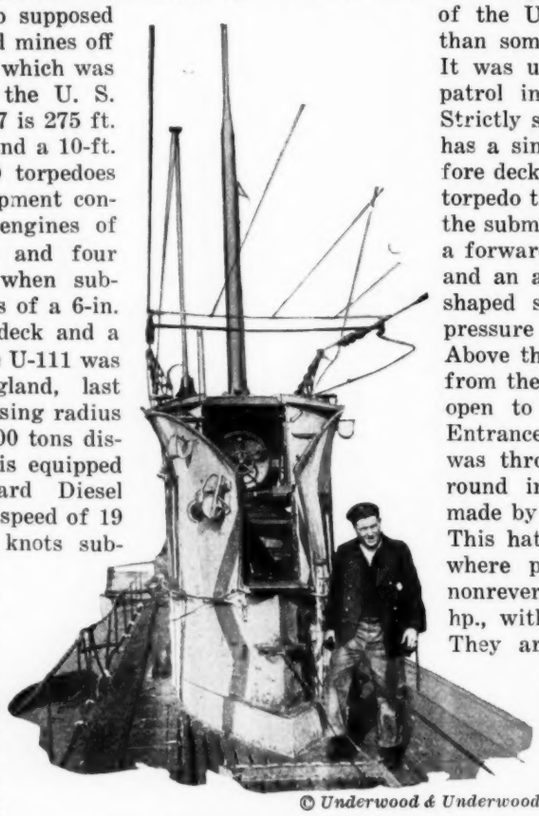


WHEN Germany was engaged in building and in operating U-boats, and especially at the time when these sea sharks were most intent upon their deadly work and meeting with considerable success in sinking ships of the Allied and neutral nations, that country did not dream that some of these same submarines would be sent 3000 miles across the Atlantic to assist in putting over the Fifth Liberty Loan in America. However, that is just what has happened, and the first one to reach American waters, flying the American flag, was the surrendered German submarine U-111. This was followed few days later by the U-117.

It is known that the latter craft is one that attempted to strike terror along the Atlantic Coast by sinking fishing boats and coal barges. This submarine was put into commission by the Germans in 1917 and operated off the North Atlantic Coast in that summer and during the summer of 1918. It is also supposed that this boat is the one that laid mines off the shore of Long Island, one of which was responsible for the sinking of the U. S. Cruiser "San Diego." The U-117 is 275 ft. in length, has a beam of 17 ft. and a 10-ft. draft. It has a capacity of 20 torpedoes and 45 mines. The engine equipment consists of two four-cycle Diesel engines of 1200 hp. for surface cruising and four 500-hp. motors for operation when submerged. The armament consists of a 6-in. rapid-fire gun on the forward deck and a 5-in. gun on the after deck. The U-111 was surrendered at Harwich, England, last December. This boat has a cruising radius of about 7000 miles. It is of 800 tons displacement, is 240 ft. long and is equipped with a port and a starboard Diesel type of engine. It can make a speed of 19 knots on the surface and 10 knots submerged. The armament consists of two 4.4-in. guns mounted fore and aft on deck, and the boat has four bow and two stern torpedo tubes. A 6-ft. saw is fitted to the bow for cutting submarine nets. At the bottom of this page is shown a near view of the conning tower, part of the controlling apparatus and the periscope of the U-111. Figs. 2 and 3 give an idea of the complicated mass of apparatus that is nested below deck. Fig. 2 is a view of the two Diesel engines of the U-105 and Fig. 3 is a view of the torpedo room, showing in the background the four tube breeches from which the torpedoes are launched. In the foreground on either side can be seen the reserve torpedoes.

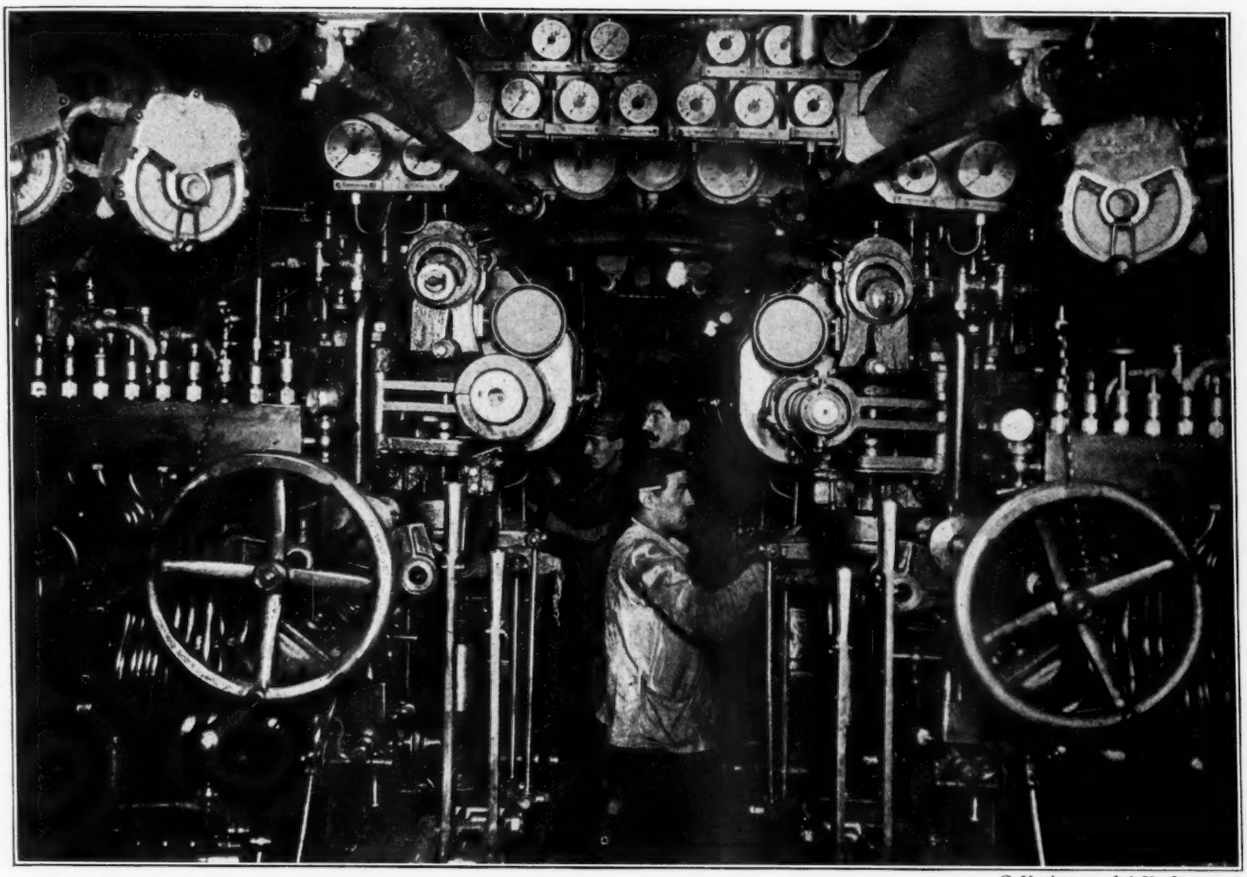
A few days after the U-111 reached New York, several other submarines with the mother ship "Bushnell" arrived at the same port. They were the U-117, U-140, UB-148, UB-88 and the UC-97. Fig. 4 shows four of these boats tied up at the Brooklyn navy yard, and Fig. 5 is a view of one of the boats as it was approaching New York Harbor, the photograph having been taken from an airplane. The UC-97 is shown in the title illustration as it was nearing the harbor.

It was the writer's privilege to make an inspection of the UC-97, which, although smaller than some of the others, is of interest. It was used by the Germans for coast patrol in French and English waters. Strictly speaking, it is a mine layer. It has a single 4.1-in. gun mounted on the fore deck and is equipped with one stern torpedo tube. Stepping upon the deck of the submarine, one sees a conning tower, a forward hatch, a 4.1-in. rapid-fire gun and an after hatch. The hull is cigar-shaped so as to better withstand the pressure of the water when submerged. Above the hull a superstructure extends from the bow nearly to the stern and is open to the sea; this forms a deck. Entrance to the interior of the UC-97 was through the after hatch, which is round in shape, and the descent was made by means of a flexible iron ladder. This hatch opens into the engine room, where port and starboard oil-burning nonreversing Diesel engines, each of 300 hp., with single camshafts were found. They are of the four-cycle type with inclosed frames, and each engine has six 10-in. diameter 14-in. stroke cylinders. At normal speed the engines run at between 400 and 450 r.p.m. The pistons are of the trunk noncooled type. The



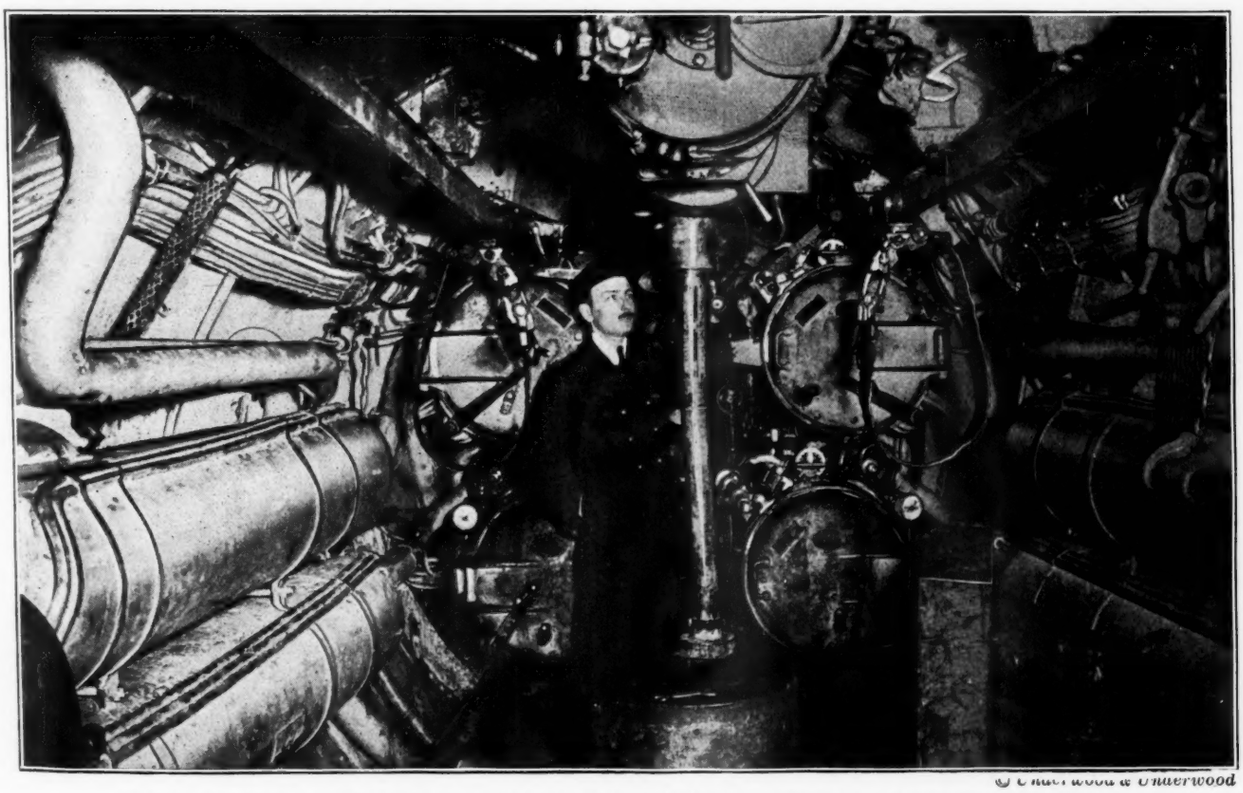
© Underwood & Underwood

FIG. 1. VIEW OF CONNING TOWER FROM REAR



© Underwood & Underwood

FIG. 2. ENGINE ROOM OF U-BOAT SHOWING TWO INTERNAL-COMBUSTION ENGINES



© Underwood & Underwood

FIG. 3. TORPEDO ROOM OF U-105, SHOWING FOUR TORPEDO TUBES AND RESERVE TORPEDOES

compression in the cylinders ranges about 500 lb. per square inch.

Having heard so much regarding the workmanship of German mechanics, the appearance of the engine and in fact all of the apparatus below deck was a disappointment. The outside finish of the engine castings is rough, and polished brass and steel are noticeable by their absence.

A fuel pump is attached to the forward end of each engine together with a distributor. Fuel oil is carried in tanks constructed on the outside of the hull. The circulating water from the engine jackets is piped to the bridge so as to obtain a head and then is returned to the oil tanks for the purpose of forcing the fuel oil from the tank into a small gravity tank in the engine room, from which it flows to the engine fuel pump by gravity.

A handle moved over a quadrant regulates the feed of the oil supply to the engine by permitting one or more of several valves to remain closed or open, depending on whether much or little oil is required. When all valves are closed, the cylinders are getting all the oil that the pump can supply. With one or more of the valves open, the oil passing through then is bypassed to the section of the oil pump. As the pumps had not been taken apart, the construction of the oil pump is not known, but it appeared as if the movement of the lever over the quadrant opened one or more bypass needle valves, all depending upon the position of the lever. Of course all instructions and markings are in German and consequently much is shrouded in mystery to the casual observer. However, it is evident that the method of governing the engine speed was by controlling the amount of oil discharged by the pump, the plunger travel remaining constant.

In the engine room are four compound-wound interpole generators mounted in pairs on the same shaft and coupled to the engine by means of a clutch. Each generator is of 100 kw. capacity, rated at about 130 hp. when running as a motor at full load. They are small for the service required, and are cooled by air that has passed over coils located below the deck through which sea water is circulated.

The storage batteries are charged by the main generators when the boat is operating on the surface. When submerged, the clutches of the engines are thrown and the generators are operated as motors taking energy from the storage batteries. Air for discharging the torpedoes, emptying submerging tanks, etc., is supplied by a motor-driven direct-connected vertical-type compressor.

Forward of the engine room is the switchboard room for controlling all electrically operated machines. These are placed on both sides of the passageway that runs from the stern to the forward compartment where the mine tubes are located. Each compartment bulkhead has a water-tight door so that the compartment can be sealed off from the others. These doors and, as a matter of fact, the passageway also are so narrow that a man can pass through with but a little room to spare.

Forward of the switchroom is the control room, directly below the conning tower, which is reached by means of an iron ladder. The flooring of the conning tower is of grating hinged to permit of opening upward. The control room contains apparatus for steering, firing torpedoes, planting mines and for emptying or filling the submerging tank. In fact, this room is the brains of the submarine. In the conning tower many of the control elements are in duplicate, such as the torpedo discharge, steering, etc. As is the practice on most submarines, steering is accomplished by electric motors, arranged in duplicate. One is in the control room and in the case of the UC-97 another motor is located in the stern torpedo-tube room. This permits steering the boat in case of accident to the forward steering gear. The control room is a mass of valves, levers, gages and indicators, and every part of the space is utilized. The depth a submarine is below the surface is determined by a depth gage, and the boat is kept at any desired depth by admitting or discharging water into or out of the

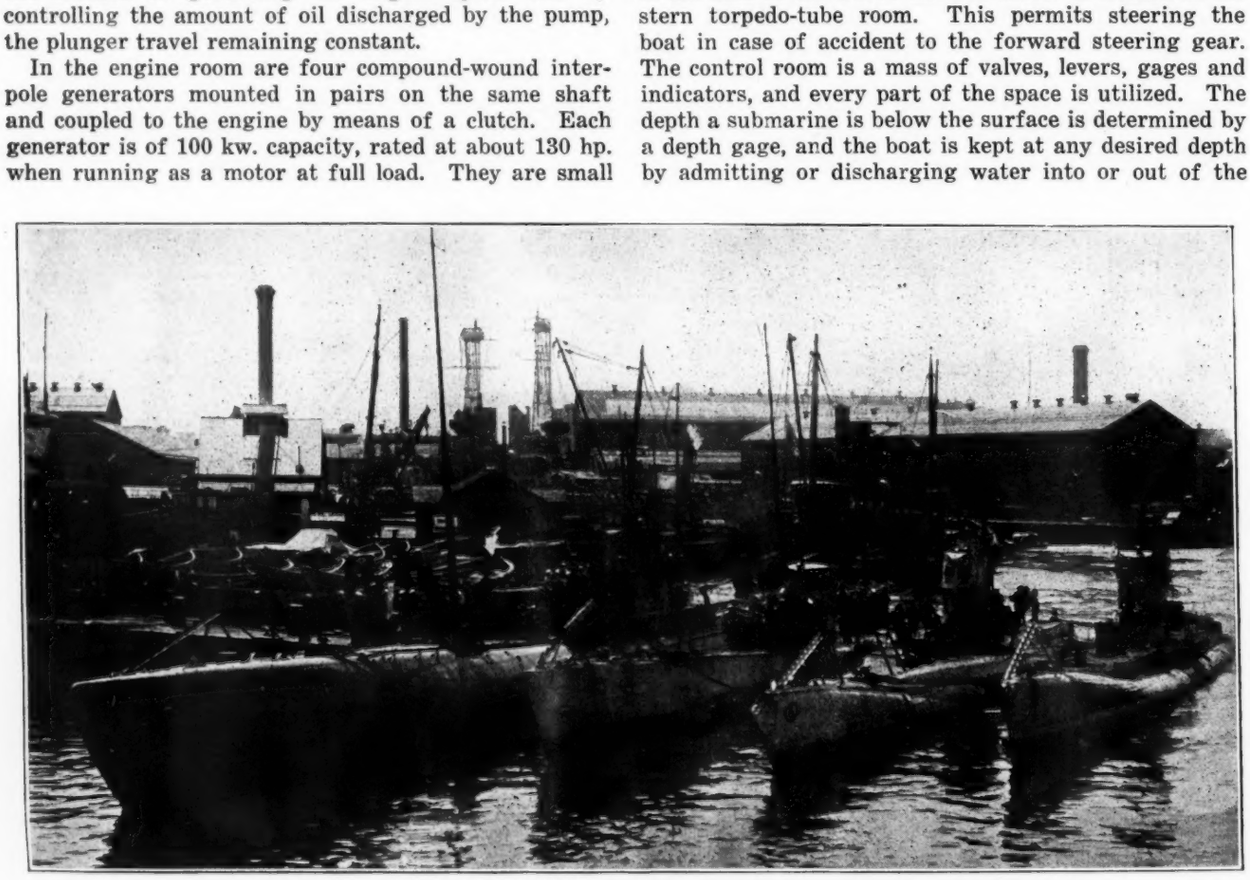


FIG. 4. SURRENDERED GERMAN U-BOATS AT THE BROOKLYN NAVY YARD

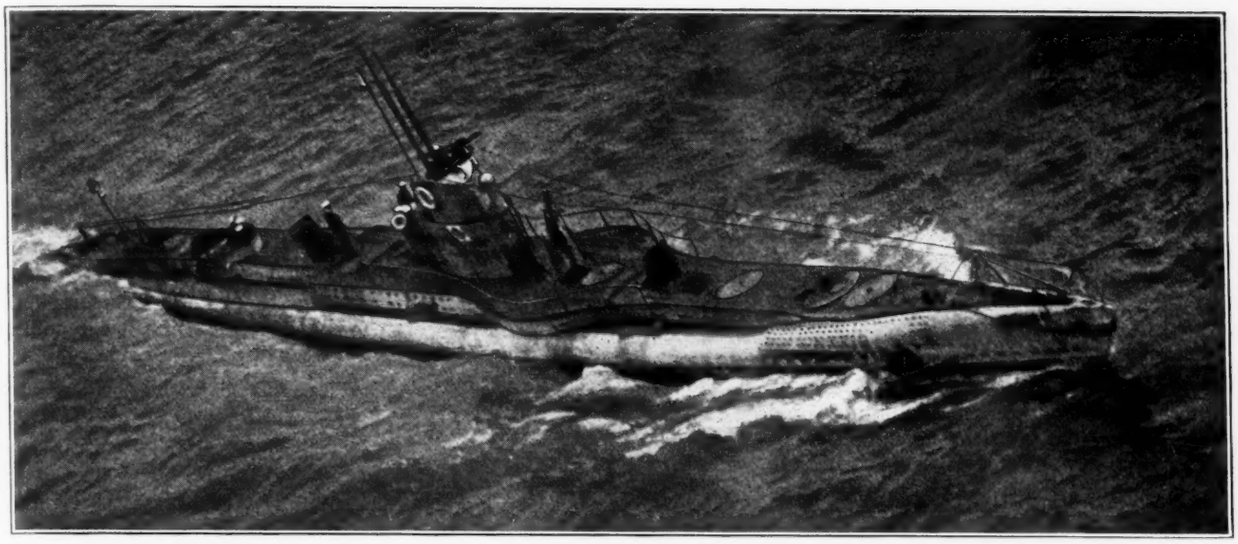


FIG. 5. VIEW OF THE U-148 TAKEN FROM AN AIRPLANE AS IT NEARED AMERICA'S SHORES

submerging tanks. By this means the boat can be held to within two feet of any desired depth.

The periscope is of the housing type; that is, it can be quickly raised and then drawn down after the observation. When at its extreme height, it extends about twelve feet above the conning tower. The boat had been equipped with two periscopes, but one had been removed. At the base the periscope is about 4 in. in diameter, but at the top it is greatly reduced so as to reduce to the smallest degree the danger of detection due to the wake of the moving submarine. A periscope has, when extended, a range of vision of about six miles on a clear day with the boat cruising on the surface. The periscope on the UC-97 is hoisted and lowered by means of a motor.

Forward of the control room are the officers' quarters and a radio room just large enough for a man to squeeze in. A door shuts out the surrounding noise. Forward of the official quarters, which consist merely of berths equaled in comfort by those found on most any small motor boat, are the mine-laying tubes.

These tubes are arranged in an upright position, but slant toward the stern. Each of the six tubes contained three mines. These are planted when the boat is in motion, being discharged from the bottom, one at a time, the boat passing over them before they rise to the position in which they are to float. When the mines are all planted, the boat goes back to its base and after reloading returns to the work of laying more mines. This type of boat caused the English shipping circles and navy all kinds of worry, for although a channel might be swept clear one day, the next morning would find the path of incoming and outgoing vessels strewn with high-explosive mines planted during the night by the UC-97 and others of her class.

The cook's galley, if it can be so called, is alongside of the mine tubes. Electric cooking kettles were used, and the meals must have been of the simplest kind. The cook worked within a foot of the six mine tubes and was encouraged in his task by being backed up by T.N.T. mines. The crew ate in the cook's room and slept on canvas bunks. The crew of this boat is assumed to have been about 30 men.

The UC-97 of course is much smaller than many of the German U-boats, some of which were really small cruisers which developed several thousand horsepower.

It was estimated that Germany had built, prior to the armistice, 331 submarines of various types, of which 158 had been sunk, leaving 173, of which only 147 were suitable for sea operation. Either the estimate was too high or more boats were sunk than was estimated, as Germany did not have the 160 submarines demanded by the original terms of the armistice. It is reported that 122 submarines were surrendered to the Allies and that over 200 were captured or destroyed and that the Germans destroyed 14 themselves. Something like 170 were being built in German shipyards when the German navy ingloriously surrendered the larger number of its ships without firing a gun.

Solder for Electrical Machinery

By R. Pittman

Soldering fluxes may in general be divided into two classes, corrosive and noncorrosive. The corrosive mixtures are sometimes termed acid fluxes, from the fact that they usually contain an acid in their composition. The noncorrosive fluxes, of which tallow and resin are examples, are those which do not react chemically with the copper. Their purpose is simply to reduce the oxide coating on the metal so that the solder may obtain intimate contact with the metal. A corrosive flux may be easily distinguished from one that is noncorrosive by coating a clean piece of copper with the flux and observing whether it is discolored after a week's time. A quicker test is to make an emulsion of the flux in water and test with litmus paper.

In general, noncorrosive fluxes only are specified for the soldering of electrical connections. However, since in soldering by dipping, all the flux is oxidized and none remains to corrode and increase the resistance of the joint, an acid flux is permissible for this class of work. Since the action of the acid is to not only reduce the oxide, but also, to a certain extent, eat through existing oxide, this flux is more rapid in its action, and hence a more desirable one for this class of work.

Before the time of war prices, pure tin was used to a large extent as a solder. However, when the price of tin became very high, considerable saving was effected by diluting it with lead. It is with the proper-

ties of solders made up of different proportions of these two constituents that this article is concerned. The effect of different proportions on the melting point, on the amount of copper dissolved by the solder and on the temperature at which the mixture works best are the important points to be considered.

A high melting point is generally considered a requisite of this class of solder. It is assumed that if a solder of low melting point is used, an electrical machine may get so hot under certain unusual conditions that the solder will be sufficiently softened to be thrown from the conductors by centrifugal force. The lowest melting point occurs at a temperature of 345 deg. F., with a mixture of 60 per cent. tin and 40 per cent. lead. Before an armature could attain such a temperature, the insulation of the winding would be charred and short-circuited, and the machine made inoperative. The accompanying table gives the melting points of solders made up of tin and lead:

MELTING POINTS OF SOLDER CONTAINING VARIOUS PERCENTAGES OF TIN AND LEAD

Per Cent. Tin	Per Cent. Lead	Deg. F. Melting Point	Per Cent. Tin	Per Cent. Lead	Deg. F. Melting Point	Per Cent. Tin	Per Cent. Lead	Deg. F Melting Point
100	0	440	65	35	347	30	70	475
95	5	422	60	40	345	25	75	500
90	10	403	55	45	348	20	80	525
85	15	387	50	50	353	15	85	554
80	20	373	45	55	385	10	90	573
75	25	360	40	60	418	5	95	600
70	30	352	35	65	445	0	100	640

The amount of copper lost in the process of soldering through the corrosive action of the tin is usually regarded as negligible. This is true for all soldering mixtures low in tin. The tin is the agent that dissolves the copper, the lead showing no desire to attack it at soldering temperatures.

Testing the Mixture for Percentage of Tin

A close analysis of pieces of copper soldered by dipping indicates that in the solder removed as a coat on the piece, the percentage of tin is much greater than that of the lead. This indicates that as the process continues, the soldering mixture is gradually deprived of its tin, until a point is reached where the percentage of tin is so low that the pieces are poorly soldered. This shows the necessity of frequent determinations for the percentage of tin in the mixture where dip soldering is being done. A very simple means of making this test is to procure a mold of known volume, preferably of one cubic centimeter, and find the weight of this volume. If W represents the weight of the sample (1 cubic centimeter), the percentage of tin may be calculated by the formula,

$$\textit{per cent. tin} = \frac{(20.6 - 1.835W)}{W} \times 100$$

As a check on the foregoing, the amount of lead may be calculated by the formula,

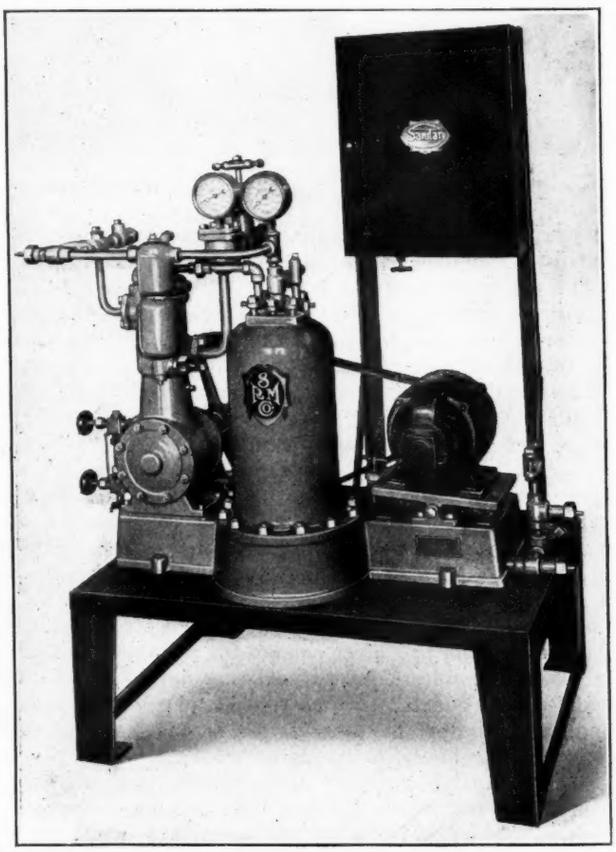
$$\textit{per cent. lead} = \frac{(2.825W - 20.6)}{W} \times 100$$

The desirable operating temperature for the solder is one at which the flux used will just keep the parts to be soldered free of oxide. The rate of oxide formation depends directly on the temperature of the solder and upon the amount of lead. The temperature to be used is a matter best left to the judgment of the operator. The three universal rules for the successful soldering of electrical connections are: (1) Have the parts to be soldered free from dirt and oxide; (2) have the parts as hot as the soldering metal; and (3) have the metal hot enough to flow easily.

The "Sanitary" Small Refrigerating Machine

A small refrigerating machine using ammonia, and particularly suited to restaurants, markets, hotels, apartment houses—anywhere in fact, where small capacity is demanded—has been developed by the Sanitary Refrigerating Machinery Co., of Milwaukee, Wis. The complete machine, exclusive of the cooling coils, is shown in the illustration.

The unit is driven by a ½-hp. motor, the normal energy consumption being 525 watts per hour of operation. The amount of water for condensation of the ammonia gas is approximately 15 gal. per hour. To charge the



THE "SANITARY" REFRIGERATING MACHINE

machine 10 lb. of anhydrous ammonia is needed, this charge lasting from 12 to 15 months.

The machine is capable of caring for a box not to exceed 500 cu.ft. interior volume at from 35 to 40 deg. F. The control is automatic by means of a bimetal thermostat which controls a relay to the motor and also controls the flow of condenser water. The shipping weight is 700 lb.; the compressor cylinder is 2 x $2\frac{3}{16}$ inches.

The longevity of the steam engine built a generation ago is demonstrated by some figures given by F. Parr, the water-works manager of Bridgewater, according to *The Engineer*. The pumping is done by two beam engines built by James Watt & Co., of Birmingham, in 1877, and working at a pressure of 10 lb. per sq.in. The repairs bill in 1914 was only £4 12s. 8d., and in 1917 was just over £16 10s. The fuel consumption is not quite a ton a day, and the duty of the pumps 375,000 gal. per day.

EDITORIALS

The Engineer as a Social Economist

AT A RECENT gathering of engineers Professor L. P. Breckenridge, who had just returned from his annual tour with the senior class in mechanical engineering of the Sheffield Scientific School at Yale, gave striking expression to a thought which has been gaining form in many minds.

He had stood, he said, at East Pittsburgh and looked down the throat of a great hydraulic turbine designed to develop forty-five thousand horsepower. His first job after leaving college was testing waterwheels with Clemens Herschel at the Holyoke flume. They had less than thirty thousand horsepower, but that "rush of many waters" used to seem to him to be enough to run the universe. Yet here was a single turbine that would drink it all up and call for more. And he marveled at the skill of the engineer who had devised that mechanism that in a few feet of correctly fashioned guides and blading could take the energy out of this flowing mass and, without impact or friction or eddy or confusion, deposit it, quiet and harmless, in the tailrace, its energy converted to the beneficent purposes of industry.

And then they were taken to the stoker department and shown how the black, smudgy, smoky coal was converted into a mass of glowing white incandescence and, after flowing through a few properly proportioned passes of the boiler, escaped as a comparatively cool and colorless gas into the atmosphere, having left some three-quarters of its energy in the steam; and he admired the skill that fashioned the apparatus and controlled so completely the process of converting this great quantity of heat energy at such temperatures without even discomfort to the operators.

And then there were the boilers, each joint and element designed and constructed by the skill of the engineer to withstand with a large reserve of security the enormous pressure upon them; and the turbine where, within a space that could be spanned by the extended arms, that steam was made to give up its energy to the revolving shaft to be converted into electricity for the service of mankind.

And then, as he rode back with his class in the train, he read in his daily paper the stories of strikes and revolutions and other manifestations of social unrest. Empires and thrones and dynasties had been overthrown; millions of people, unused to the free air of liberty, untaught in the problems of industrial administration, had been torn loose from any allegiance to constituted authority; thousands of laborers filled with a new sense of their indispensableness were clamoring for the democratization of industry as well as of the forms of government, for a voice in the determination of the conditions under which they work and live. And he wondered where the skill and tact and expert knowledge was coming from that would devise the method and the mechanism that would direct this mighty force, the man power of the world, to its beneficent purpose, the support and development of the race, smoothly, efficiently, without clash or friction or calamity.

If the water gets away, we have a Johnstown flood; if the fire gets beyond control, we have a conflagration; if the boiler is not properly designed, constructed and operated, we have an explosion; if there is friction or lack of balance in the turbine, it may wreck itself in a few revolutions.

What may be the consequences of a failure properly to understand and direct these great human forces now wasting themselves in friction and eddy and conflict and misdirection? Who better than the engineer with his analytical habit of thought and his methods of applying the forces and materials of nature in the most direct and efficient manner to the benefit of man, can outline and put into execution a plan which will unite administration and manipulation in a system of national production that can be carried at the full rate and at maximum efficiency and in which the standing and emolument of each shall be in proportion to the service rendered?

Size of Transformer for Induction Motor

THE question of the selection of transformers for induction motors is one that has frequently been given too little consideration by those who have applications of this sort to make. The rules and formula given in the article by J. B. Gibbs, on Page 756 of this issue, are extremely simple and practical and will be of great assistance to those making applications of this sort. The information given on emergency connection is of particular value in that by becoming familiar with these schemes it may be possible for an operator to save a long and serious shutdown. In using emergency connections of this kind, care should be taken to see that the reduced capacity of the transformers is given due consideration and, if necessary, the load can be reduced until proper repairs can be made.

As stated by Mr. Gibbs, according to standardization rules of the American Institute of Electrical Engineers and of the National Electric Light Association, transformers are designed to have a temperature rise of fifty-five degrees Centigrade above the surrounding air. Some motors are rated on a fifty-degree Centigrade rise for continuous operation, but there are a large number of motors sold on a basis of a forty-degree rise with the stipulation that they shall be capable of operating under an overload of twenty-five per cent. for two hours after a continuous run with a temperature rise not exceeding fifty-five degrees Centigrade. This would obviously considerably overload a transformer based on fifty-five degrees rise for full-load condition of the motor. The transformer should be either based on forty degrees Centigrade rise or the capacity increased twenty-five per cent. when rated on fifty-five degrees rise.

Where a transformer is used to supply two or more motors, the diversity factor of the various motors must be taken into account, since it is not necessary to supply a transformer having a capacity equal to the combined capacity of all of the motors. This diversity factor depends not only upon the number of motors involved, but also the class of work to which they are applied. For the ordinary machine-shop drive, this diversity will be approximately fifty per cent., which means that the capacity of the transformer feeding a group of motors in the machine shop may be about fifty per cent. of the combined capacity of the motors. For crane operation the diversity factor is very much less. The capacity of crane motors is based on an intermittent rating which is about fifty per cent. greater than their continuous rating. The motors on a crane are seldom all in operation at the same time, and in a group of cranes there are always several idle. The result is that the capacity of the transformers for a group of cranes can be about ten per cent. of the combined capacity of the various motors, based on their intermittent rating. The diversity factor of each group of motors should be given a very careful study before determining the actual size of the transformer required. As pointed out by Mr. Gibbs, if a transformer is too small, it will burn out, and if too large, there will be unnecessary energy loss in the system and an unnecessary investment in transformers.

The N. E. L. A. and Some Power Problems

AFTER a lapse of over two years, during which time its meetings were devoted almost exclusively to problems connecting the industry with the prosecution of the war, the National Electric Light Association Convention this week at Atlantic City will afford central-station men an opportunity to get together for the discussion of their normal problems, both technical and commercial. Many familiar faces will again be seen, and the important committee reports will once more be in evidence.

This year finds the industry confronted with many new conditions and problems. Normal development in certain lines was retarded to make way for the more pressing demands occasioned by the war; while in other lines exigencies accelerated development. Many companies have been handicapped through loss of skilled labor and operatives in the face of increased production demands. Moreover, it has often been difficult to obtain the desired quality of material, and labor shortage, together with inability to secure delivery of new equipment, has often rendered proper maintenance difficult.

Another factor of utmost importance is the increased cost of fuel and labor, both of which are here to stay. This calls for closer attention to operating economies and the attaining of more favorable load conditions. It also emphasizes the necessity for greater water-power development, the lack of adequate legislation regarding which has been so costly to the nation during the last few years. With a definite solution near, the closing days of the Sixty-fifth Congress again shattered hopes for early development when it let die a bill that was generally acceptable to all interests concerned. Will the performance be repeated by the new Congress or will it be spurred to action by the coal situation? Meanwhile the attitude of Secretary Lane is most encouraging. His plan for a survey of the power situation in the New England and Atlantic States section and the scheme for "Regional Power Systems" as outlined by George Otis Smith, Director of the Geological Survey, give promise of closer coöperation between the Government and central-station interests in solving the power problem.

Our many readers in large power stations particularly will find much of interest and value to them in the article on Holtwood record keeping elsewhere in this issue. The excellence of service from this large hydro-electric plant supplying power to Baltimore, Maryland, and Lancaster, Pennsylvania, is due in no small measure to the methods of recording, filing and checking data on the operation and condition of the station's equipment. It is not practicable to standardize record and report forms, but one wonders if there is excuse for the wide variety of forms found in plants similar in character. Of all the forms we have seen, certainly none were better suited to a plant than those at Holtwood. We believe many of them are applicable in other stations, hydro-electric and steam.

In his discussion of the Diesel engine in this issue, Mr. Sprado lays stress on the importance of employing high-grade men to operate them. This statement, which reflects the present view of prominent builders of this type, is most gratifying and in accord with the stand that *Power* has always maintained; although it will be recalled that four or five years ago certain other builders took quite a different view and were quick to resent such a statement. It goes to prove that an experienced and intelligent operator is one of the best assets toward establishing a good reputation for any piece of power-plant apparatus, and particularly a Diesel engine where small clearances, high pressures and high temperatures are encountered.

Regarding the difference in steam consumption in a heating system when using either exhaust steam or live steam at reduced pressure, considerable difference may be had in the results due to the design of the system. Therefore the man who claims that he burns as much coal to heat a building using live steam, and the engine shut down, as he does when using exhaust steam with the engine running, may be as correct in his conclusions as the engineer who claims that less steam is used when he utilizes the exhaust from his engine.

Dealers are very much concerned and the Government is very considerate lest the releasing of some of the surplus supplies that it accumulated should break the high prices at which the goods are at present held; but we did not notice any such concern or precaution against inflation of the price to the consumer by the exceptional demand at the time that they were bought.

It is not within the power of the human machine to turn out continuously as much work in a thirty-hour week as in a forty-four-hour week. Therefore to keep up production to meet the world's needs, increasing use must be made of machinery. This being the case, the future promises plenty of activity and opportunity for the engineer.

Correspondence

Loose Connection Causes Motor Troubles

A 10-hp. 500-volt direct-current motor was giving trouble owing to the fuses blowing, but the cause could not be found. A circuit-breaker was installed in place of the fuses, but the shop was still frequently shut down, which showed that the trouble had not been removed. The motor and the starting box were taken to a shop and were given what was supposed to be a complete overhauling. When they were reinstalled and tested, the armature started very slowly and the starting-box resistance became very hot, which indicated that the field circuit was apparently open. The starter was opened up and the field circuit was found to be connected as shown at *B*, in Fig. 1. Since practically all the line voltage is absorbed in the starting resistance when the starting-box handle is on the first contact points, the voltage across the field coils is very low, hence the field current is very small. This caused the armature to develop practically no torque or pulling power, which accounted for its slow speed and the heating of the starting resistance.

By changing the field connection inside of the starting box to that at *B*, Fig. 2, the starter trouble was relieved and the motor was again put into service. In a short time the circuit-breaker opened again and caused the plant to be shut down. This showed that the trouble had not been corrected.

A study of the conditions indicated that the motor showed no bad effects and the breaker did not open from a short-circuit, but that the trouble was apparently caused by a loose connection, which opened the line for a few seconds and closed it again before the starting-box handle returned to the off position.

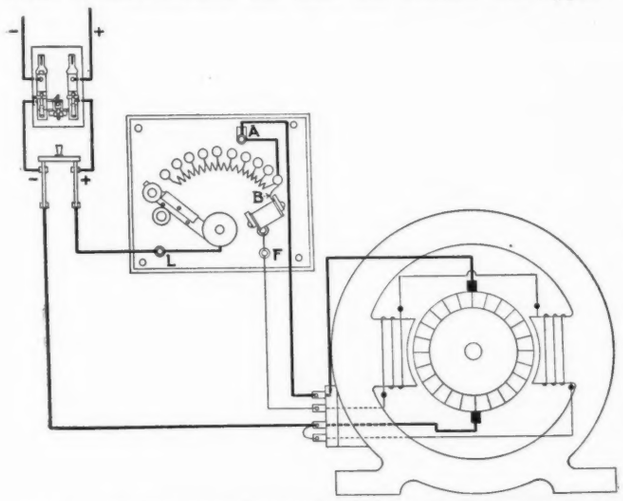


FIG. 1. SHOWS WRONG CONNECTION IN STARTING BOX

A voltmeter was connected across the switch as in Fig. 2, and watched for a drop in voltage before the breaker opened. If the voltmeter had showed a drop, the trouble would have been between the switch and source of power. But the voltage was steady, hence the trouble was between the switch and the motor. Starting at the switch all connections were examined. The armature leads were held in brass terminals by setscrews. One of these screws had worked loose, thus permitting the circuit to open momentarily at this point due to vibration. The joint was covered with tape, which held the lead in place and also made the trouble difficult to locate.

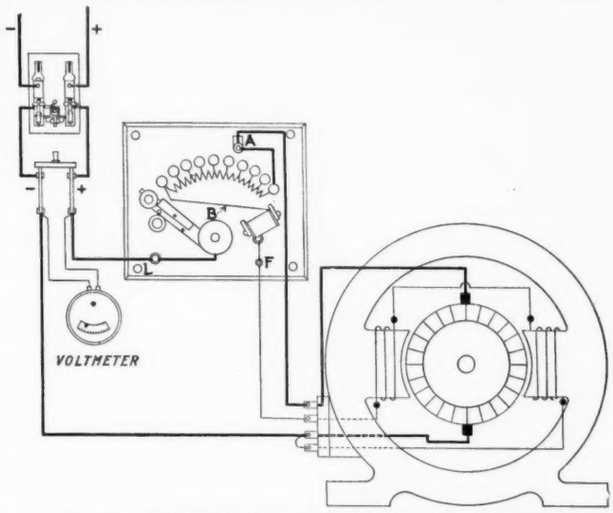


FIG. 2. STARTING BOX CORRECTLY CONNECTED

R. L. HERVEY.

Washington, D. C.

Generator Heats Excessively

In my letter, "Generator Heats Excessively," in the Feb. 11 issue of *Power*, I did not intend to create the impression that it is necessary for the armature to rub on the polepieces to cause heating, since the unequal air gaps alone are enough to produce the trouble; the greater the difference the greater the heating. I am writing from personal experience, as I had this trouble two years ago.

I have charge of the heating and lighting plant at Huron College, and we have a 50-kw. direct-current generator directly connected to a 12 x 12 engine, the main bearings of which became so badly worn that in taking up the lost motion with the wedges the armature was drawn over until it did not lack more than the thickness of a sheet of paper of touching one of the pole-faces. The generator was a six-pole compound-wound machine, and the pole nearest the armature became so hot that I could not hold my hand on the yoke; and as I could not shut down to make repairs at that time, I cut out the shunt winding on this pole and, by allowing the main bearing to run a little loose, got through the season without serious trouble.

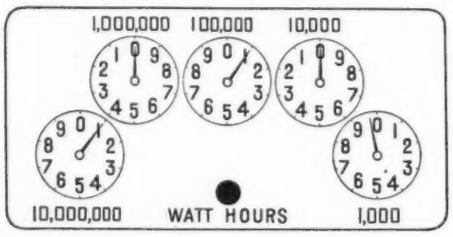
We rebabbitted the main bearing the following fall, and the generator has been running satisfactorily ever since.

JAMES N. CHALLACOMBE.

Huron, S. D.

What Does the Meter Read?

The article, "How to Read the Watt-Hour Meter," by Victor H. Todd, in the issue of March 25, has created considerable interest among the fellows around our plant, in reading watt-hour meters. However, the dial arrangement shown in the figure is one that we have



WATT-HOUR METER DIAL

not been able to agree upon as to just what the correct reading is. I am therefore submitting this problem to the readers of *Power*, thinking that some of them will give the correct reading and the reason for their interpretation.

CHARLES A. ARMSTRONG.

Philadelphia, Penn.

Firing-Door Arch Construction

Brick linings at the sides of the furnace fire-doors had to be replaced frequently due largely to being broken by fire bars and cleaning tools. A pattern of 1-in. pine board was made as shown in Fig. 1, and castings were made the width of the deadplate and the height of the brickwork at the sides of the fire-doors,

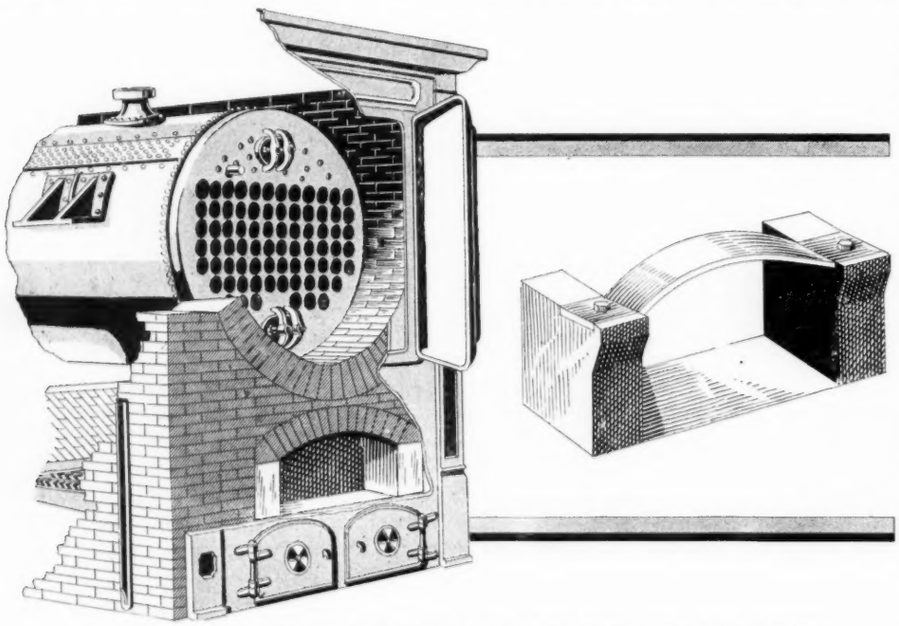


FIG. 1. APPLICATION AND DETAILS OF ARCH BAR AND SIDE PIECES

in this case about 14 in. The slanting notch and the projecting piece at the top were to hold the ends of the cast arch bars which extend across the fire-doors and support the front arch bricks. This notch prevented the arch bars from creeping toward the fire. The bars were about 1 in. thick and 5 in. wide. By drilling a $\frac{5}{8}$-in. hole in each end in the flat part and slipping in a bolt two or three inches long, the plates were prevented from moving. Before using these plates, the front arch had to be relaid once or twice a year, but the plates lasted two or three years, and, until they were burned back too far to hold the arch bars no relaying of the arch was required.

A leak would sometimes occur around the long through rods which extend from end to end of the return-tubular boilers. After trying several kinds of gaskets, such as asbestos, wire gauze, red lead and iron filings without satisfactory results, a mold was made

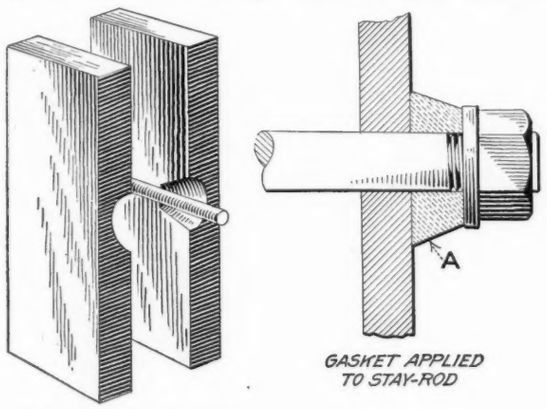


FIG. 2. MOLD AND APPLICATION OF LEAD GASKET

of two pieces of boards clamped together and a hole bored through them in the center the size of the through bolt, then cut out each half tapering about $\frac{1}{2}$ or $\frac{3}{4}$ in. deep, as shown in Fig. 2. A piece of tube or pipe was then placed in the hole the size of the rod and all clamped in a vise and lead poured in the mold, which made a tapered lead gasket as shown at *A*. This gasket was slipped on over the rod with the large washer, and when the nut was screwed up tight the leak was permanently stopped.

Trouble was also experienced with the cast-iron collector rings on the alternator, due to burned spots on them equidistant between the brushes. As the rings are case-hardened, it was almost impossible to smooth them up. An old wire-gauze alternator brush was sawed down to the size of the carbon brushes on the rings, and one was put on each ring in place of the carbon brush. As a result in a short time the burned spots had disappeared and then the metal brushes were replaced with the carbon until the rings began to spot again. The metal brushes will run somewhat hot, but they will true up the rings.

Many methods have been employed in truing up burned rings. My way is so simple that anyone can use it without the expense and trouble of making apparatus to do the job.

LE ROY MILLER.

Sodus, N. Y.

Hand-Damper Regulation Bonus

On page 328 of the Mar. 4 issue is an article by John F. Hurst, on "Hand-Damper Regulation." I am a firm believer in the uptake control, and where a firm or company is so poor or penurious that they cannot or will not purchase a good damper regulator, the idea of P. Henwood, published in a previous issue, is all right, but the best fireman in the universe cannot regulate his draft at all times as nicely or efficiently as will a good hydraulically operated regulator.

I had an opportunity a few years ago to see this nicely demonstrated. The fireman was an exceptionally good man and tried his best to get results, but in spite of his good will and best endeavors, the safety valve would blow occasionally and steam would drop a little at times.

The engineer was also the machinist for the shop, and so the fireman oiled the engine and pumps. One day as I was passing, the "old man," as we all called the fireman, asked me what I thought of the idea of operating the damper automatically and I told him that almost anyone who made any pretense of being bright had done that trick for some years.

"Do you do it?" he asked me point blank, and I don't know to this day whether he meant it for a joke or otherwise, but I told him that I had an ancient edition that did not regulate within 8 pounds.

He told me that the makers of a certain regulator guaranteed it to hold steam within one pound and that his company was going to give it a test. The regulator was installed and McNally gave it a test. He fired as faithfully as he knew how and they weighed the coal; a water meter was on the boiler line.

This line supplied the faucet at the sink and the hose connection for wetting the ashes and then fed through a closed heater into the boiler. A feed pump could be put in operation if the town pressure fell below a certain point, which it did at times.

The meter was always read once a week, on Sunday, so they knew approximately what the boiler was doing.

The boiler was operated the first week with the new regulator working as nicely as they guaranteed. The next week the boiler was fired without the regulator working and the fireman did his level best to beat the regulator, but he fell short by several hundredweight of coal, and the water meter showed a little more water used the week the regulator was operating; but the regulator was taking from the line, which accounted for some of the water used.

Several tests were made and the saving appeared to be about 3½ per cent. The agent who placed the regulator on trial had guaranteed at least 5 per cent. and he said it might show 10, so of course he was disappointed, but anyone that knew McNally was not surprised.

Even at 3½ per cent. the regulator was a paying investment, so it stayed in the plant, but it would have shown 10 per cent. saving in fifty plants out of a hundred and probably 5 to 8 per cent. in 75 plants.

I believe in paying my firemen the highest possible wages, as well as my engineers, oilers, helpers and repairmen—with no bonus. We make cloth of varying weights and textures and cannot draw a fine line nor split a coarse line. If, after paying my men the limit, they must have a bonus to do good work, I simply drop them. I firmly believe bonus systems in a plant lead to crooked work that more than offsets the good they do.

In one plant with which I am more or less acquainted at stock-taking time the coal was always accurately estimated from the daily log, but six months after a bonus system was tried the coal fell short of the estimate by 400 tons.

The bonus system had shown a saving of 12 per cent. Stock taking showed a loss of just the amount of bonus paid. The coal consumption was neither more nor less than for the same period of the previous year, notwithstanding that the water evaporation was higher—apparently. No more product was shipped from the plant, the same amount of fuel was purchased as formerly, the grade was the same, and the only difference was a bonus paid that was not earned and a rupture caused that eventually cost the chief engineer a mighty good berth.

If I am in doubt as to whether a man who is paid by the hour has worked three or four hours overtime, I give him four and also pay time and a half. If my salaried men, who are allowed two weeks vacation per year, are sick one or two weeks, I don't call that their vacation nor deduct from their salary, but the man who tries to put something over has got to do it in such a nice refined way that I cannot detect it or he has lost his job, and the men know it.

A man who works for me will get any bonus on his merits by a raise in salary if the plant can afford it, and my men must be far enough advanced in their craft to be able to get results without signs to warn them how to do it.

Many times the fireman is referred to in an unbecoming way, which he does not deserve, and his intellect is questioned, but it is a wrong proceeding, and many a man behind the shovel or at the stoker has got just as many ounces of gray matter as the man on watch in the turbine room, and, incidentally, many a chief engineer started on the end of a coal scoop.

New York City. C. W. PETERS.

Safe Loading of Two-Phase Cables

In the loading of three-wire two-phase cables where all three conductors are the same size, the current in the center wire frequently is not considered. In a three-wire cable carrying a balanced two-phase load, the current in the middle wire is $\sqrt{2}$, or 1.41, times the current in the outside wires; so that the capacity of the middle wire is the determining factor in the loading of the cable.

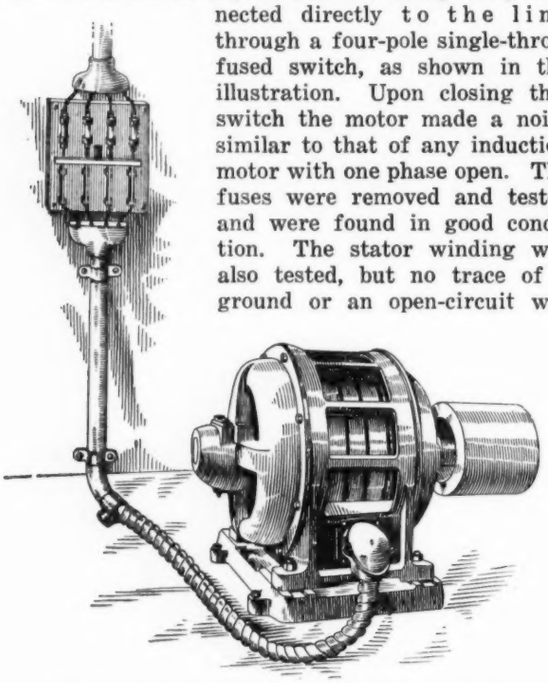
As the ammeters are always placed in the two outside wires, it is very easy for the operator to neglect the current in the middle conductor. For this reason the capacity per phase of such cables should be computed for the current in the middle wire. Thus a three-wire two-phase cable rated at 300 amperes per conductor should carry a full-load current per phase of only $\frac{300}{\sqrt{2}}$, or 213 amperes.

In the relay settings this same consideration must be made where, as is usually the case, the relays are connected only to the outside wires. Thus, if the 300-ampere per conductor cable were to be protected for 100 per cent overload, the relays should be set for $2.0 \times \frac{300}{\sqrt{2}}$, or 426 amperes, instead of 600 amperes.

Philadelphia, Penn. F. J. GILLOOLY.

Induction Motor Failed To Start

A two-phase four-wire four-pole 500-volt induction motor used to drive a small freight elevator failed to start when the switch was closed. No starting device was used with this motor, the stator winding being connected directly to the line through a four-pole single-throw fused switch, as shown in the illustration. Upon closing this switch the motor made a noise similar to that of any induction motor with one phase open. The fuses were removed and tested and were found in good condition. The stator winding was also tested, but no trace of a ground or an open-circuit was found. Upon questioning the attendant he said that he had opened the fuse clips a small amount so that he could remove the fuses easily. Upon replacing the fuses it was found that one of them was held tightly by the bottom clips, but a very small air space remained between the upper ferrule and the top clips. Thus, when the switch was closed the motor was placed across the line with one phase disconnected. Upon tightening the clips, the motor was started without further trouble.



ARRANGEMENT OF MOTOR INSTALLATION

Jersey City, N. J. JOHN H. SHAVER.

Qualifications of a Diesel Operator

Much credit for smooth operation of Diesel engines is due, naturally, to the operating engineer. A certain author in a book on Diesel engines, comparing them with gas and producer-gas engines, stated: "In this respect the Diesel engine differs from other prime movers in that its over-all fuel economy is not dependent on the efficient operation of auxiliaries, or even on the skill of the operators, as its operation is largely an automatic thermodynamic process in the engine itself. With a correctly designed and efficiently built engine this economy will be maintained undiminished during the life of the engine, provided the engine receives proper care."

Now, unless the operator is a skilled mechanic, he cannot give the Diesel engine the proper care its importance in the world of power demands. The engine requires considerable attention. Joints must be ground in to perfection to prevent leakage of air, for it requires but a small leak to cause loss of pressure.

The pressure varies from 800 to 1200 lb. per sq.in. Some gages are marked in atmospheres and others in pounds. The pressures to be used vary with the load carried, the highest existing at heavy loads, and they are regulated by the engineer by throttling the inlet to the air compressors, by bleeding the air bottles and sometimes by setting an auxiliary safety valve.

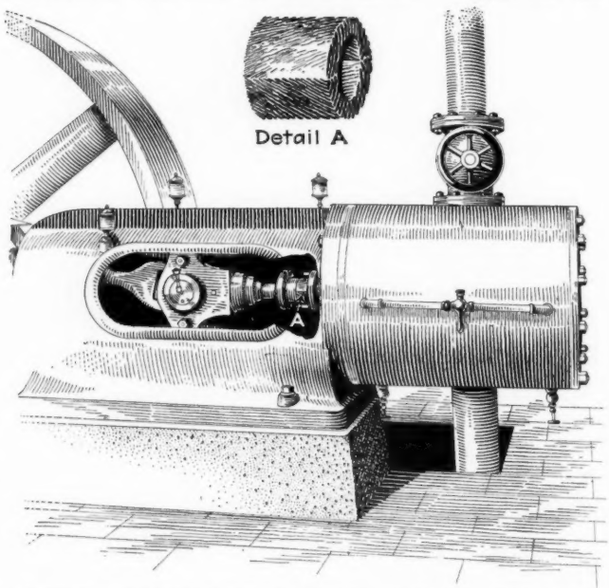
An unskilled operator will gradually become skilled, but while doing so he will cost money and will cause some unavoidable shutdowns and fuel losses. The skilled man will save money in fewer repairs, higher operating economy and reliability of operation during working hours, and the higher the grade of the man the better the over-all efficiency up to the maximum obtainable. The old story that the oil engine or gas engine requires no skilled operator has never had much of a chance to impress the erecting man. It has been exploded many a time. D. L. FAGNAN.

New York City.

Packing a Piston Rod

I use the following method in packing piston rods with fibrous metallic packing. It is necessary that the rod be smooth and running true to use such packing successfully.

I secure a wooden bushing, such as is used with wooden pulleys, which exactly fits the stuffing-box and rod, put in a small amount of packing at a time, place the bushing in the stuffing-box, jam it home with the gland, and repeat this until the stuffing-box is full. Then I jam the gland against the packing until it sets to conform with the shape of the gland. Frequently the distance between the oil splasher and the stuffing-box is very short. In such cases it will be necessary to saw the bushing off as the stuffing-box fills with packing. Do not attempt to jam the packing in with the gland, as it will not stay square in the stuffing-box.



USING WOODEN BUSHING WITH FIBROUS METALLIC PACKING

Kansas City, Mo. E. J. SCHAEFFER.

The *Locomotive*, published by the Hartford Steam Boiler Inspection and Insurance Co., lists 39 flywheel explosions as having occurred during the year 1918. Up to and including September of the same year it records 314 boiler explosions.

Inquiries of General Interest

Too Much Blowdown of Safety Valve—If a pop safety valve that was set at 90 lb. is adjusted to blow at 70 lb. and the valve does not shut off until the steam pressure of the boiler drops to 60 lb., what should be done? H. A.

Safety valves of boilers carrying an allowed pressure of less than 100 lb. per sq.in. gage should close after blowing down not more than 4 lb. If the safety valve, when set to blow at 70 lb., does not close until the steam pressure falls to 60 lb., thereby allowing 10 lb. blowdown, the blowdown should be adjusted so the valve will close at not less than 70 − 4 = 66-lb. pressure.

* * *

Travel of Cylinder Over Piston—I claim that at times the cylinder of a locomotive travels over the piston, while B and C claim it would be impossible. Which is right? F. J. S.

Motion of a body is change of its position with reference to the position of a point, a line, or another body. Regarding a railroad track as a stationary object to which motion of the parts of a locomotive are referred, when the locomotive is going forward, the cylinder is carried forward at the speed of the locomotive, and during a stroke of the piston from the head end of the cylinder, it is not moving forward as fast as the cylinder and the cylinder may be said to pass over the piston in the same way that a boy might make a running jump and pass over the head of another who is walking slowly in the same direction.

* * *

Equivalent Evaporation at Different Feed-Water Temperatures—How many pounds of feed water at 212 deg. F. evaporated into steam at 70-lb. gage pressure would be equivalent to the evaporation of 30 lb. of water from a temperature of 100 deg. F. into steam at the stated pressure? J. R. C.

A pound of steam at 70-lb. gage pressure, or 85 lb. absolute, contains 1183.4 B.t.u. above 32 deg. F., and evaporation of 30 lb. of feed water from a temperature of 100 deg. F. into steam at 70-lb. gage pressure would require [1183.4 − (100 − 32)] × 30 = 33,462 B.t.u. For evaporation from a temperature of 212 deg. F. into steam at 70-lb. gage each pound of feed water would require 1183.4 − (212 − 32) = 1003.4 B.t.u., and to obtain an evaporation into steam at 70-lb. gage pressure equivalent to conversion of 30 lb. of feed water from a temperature of 100 deg. into steam at 70-lb. gage pressure would require the evaporation of 33,462 ÷ 1003.4 = 33.35 lb. of the feed water at the temperature of 212 deg. F.

* * *

Determining Lap and Lead of D-Valve—How can the steam lap and lead of a D-slide valve of an engine be determined without removing the steam-chest cover? E. M.

Make a mark on the valve stem at the end of the stuffing-box gland when the stem is farthest in, and another when it is farthest out of the stuffing-box, and halfway between these marks locate another mark to represent the mid travel of the valve. Then turn and block the engine wheel to such a position that steam will be just admitted to one end of the cylinder with the throttle valve open only a little, as shown by the escape of steam from the open cylinder pet-cock on the same end of the cylinder. Make a mark on the valve stem at the end of the stuffing-box gland and locate a similar mark with the valve just opening on the other end. The distance between these latter marks will be equal to the sum of steam laps of both ends of the valve, and the distance that each one is from the mark previously made to register the mid travel will be the amount of steam lap on corresponding ends of the D-valve. To determine the lead at either end, place the engine on a center and make a mark on the valve stem at the end of the stuffing-box. Note the distance of this mark from the mark made for registering the beginning of opening of the same end of the valve. If the engine would have to be turned backward to obtain the registration of the opening, then the distance so noted would be the amount of positive lead, but if it would have to be turned forward, the distance would be the negative lead, or amount the valve would lack of being open at the beginning of the stroke.

* * *

Shell and Core Type Transformers—What is the difference in construction in shell-type and core-type transformers? K. B. A.

In the shell-type transformer the coils are assembled and then the core is built up, of thin sheets of soft iron, around the coils, as shown in Fig. 1; and in the core-type the coils are placed around a core built up of thin sheets of soft

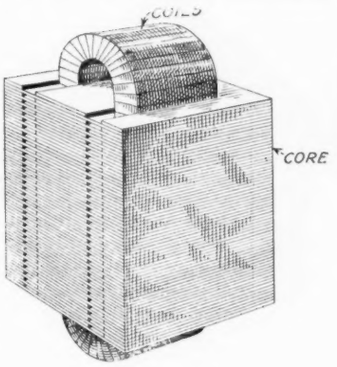


FIG. 1

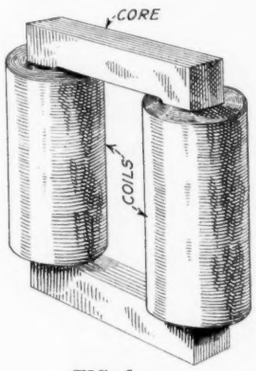


FIG. 2

iron in the form of a square link, as shown in Fig. 2. The arrangement shown in Fig. 2 is the one generally used for core-type transformers, and the one given in Fig. 1 is only one of a number of arrangements for the core and coils of shell-type transformers, but they all follow the general idea set forth in this figure.

* * *

Data for Ordering Pinion—If the pinion to an elevator should be broken beyond repair, what data should be sent to the factory to secure a wheel to replace the broken one? W. H.

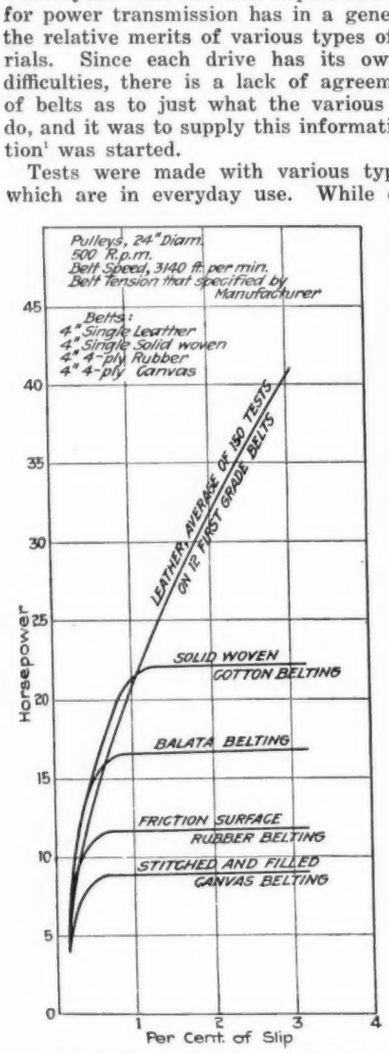
When ordering of the maker, state the purpose of the wheel, and give the pattern number if it bears one. The order should state whether a cut or cast gear is to be supplied. Give an accurate measurement of the working distance between the center of the pinion and center of gear wheel with which the pinion meshes, and the number of teeth and outside diameter of each, and furnish a drawing or templet the shape of a segment of the gear wheel that will include eight or ten teeth, showing their shape marked off from the wheel on a sheet of tin plate or cardboard, and state the desired width of face of the teeth for the pinion. Also state the length of hub, how much each end of the hub is to be offset under or beyond the teeth; whether ends of hub are to be finished, diameter of bore, size of setscrew, size of keyway in shaft, whether new key is wanted and from which end of the hub key is to be driven.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Comparison of Belt Materials

Everyone who has had experience in the use of belting for power transmission has in a general way decided upon the relative merits of various types of belts and belt materials. Since each drive has its own characteristics and difficulties, there is a lack of agreement among the users of belts as to just what the various types of belting will do, and it was to supply this information that the investigation[1] was started.

Tests were made with various types of pulleys, all of which are in everyday use. While different results were obtained with different pulleys, the ratios between the various types of belting materials remained the same. That is, although leather on paper pulleys showed higher results than on iron, so also did balata and rubber, and the advantage of leather over other materials remained unchanged.



RELATION OF BELT SLIP TO HORSEPOWER

In all tests the pulleys used were 24 in. in diameter, some were crowned and some straight face. In the series of tests on the first set of machines the belt was run at 3770 ft. per min., while in the series run on the second set of machines the belt speed was varied from 2500 to 5000 ft. per min. Most of the tests were made at 500 r.p.m., or a belt speed of 3140 ft. per minute.

Tests were made at a number of tensions in order to determine whether or not the relative capacities of the belts changed with changing tension. The light running tension varied from 35 to 75 lb. per inch of width, which corresponds to approximately 45 to 90 lb. per inch of width when the belt is standing still. The difference between the tension of the belt standing still and running under no load is due to centrifugal force. Most of the data here presented are based on tests in which the tension was a little higher than that advised by the manufacturers of the various belts, and ranged from 50 to 70 lb. per inch of width when the belt was standing still.

The tests were conducted by increasing the load on the belt from zero to a point where the slip amounted to at least 3 per cent. and the belt showed signs of distress. Measurements of speed, tension and horsepower were made at each step. The horsepower transmitted by the various belts at different percentages of slip is shown in the illustration.

The curves show that fabric belts all possess a definite maximum beyond which it is impossible to go, and that the points of maximum power-transmitting capacity are below the safe load for leather belting. The leather belts at this speed are rated from 20 to 25 hp. The curves show that leather belting operating at 25 hp. has an overload capacity of 60 per cent., while not one of the fabric belts, operating with no factor of safety at all, can carry such a load. While it would not be advisable to operate belts at their full capacities, it is important to know just what margin is available for overloads.

The results of these tests indicate the following:

1. Leather belting possesses a much greater power-transmitting capacity than fabric and in the ratios shown in the illustration.

2. The enormous advantage of leather over all the substitute belts persists at all speeds up to at least 5000 ft. per min., and at all tensions within the range practicable for power transmission.

3. The relative capacities of the various belts remain the same on various kinds of pulleys.

4. Leather belting, at its rated horsepower, possesses a big overload capacity, while the fabric belts at much lower horsepower possesses no overload capacity whatever.

5. Leather belting improves with age, while the fabric belts are at their best when new.

6. Wherever a fabric belt of a given width is carrying its load with some degree of success, a suitable leather belt three-quarters as wide will do better work than the fabric.

Leather is peculiarly suitable as a material for belting. It has great tensile strength; it is tough, pliable, flexible and practically indestructible. There are in existence pieces of leather that are known to be hundreds of years old, still strong and full of life. Time has no effect on its chemical construction. Water or dampness does not injure it, and it does not rust, corrode, crystallize or disintegrate. It is injuriously affected only by certain acids, and it wears slowly from the results of friction. A leather belt, properly proportioned to its work and of a suitable character, will give service for a long time with reasonable care.

Should a leather belt outlast its first installation, it may be cut to a narrower size, shortened or lengthened and the remodeled belt is as good as ever. When it has become old and beyond the repairing ability of the mechanic of the shop, it can be rebuilt by its maker, the bad places cut out, the good retained, and sufficient new added to make the proper length. It is then good for many more years of usefulness. When repairs become inadvisable, it still has a value for repairing other old belts, or for straps, brake shoes, heel taps, etc. The last remnant of it is worth something to somebody.

None of these statements is true of the substitutes for leather belts. They cannot be cut down into other sizes, repaired or rebuilt, and when finally discarded they have no salvage value. Some of these belts have a low first cost and others approximate the cost of the leather belt; but all of them, calculated on a basis of the cost of transmission per horsepower per annum, will be found to cost many times the price of the best leather belts.

In a paper on boiler mountings recently contributed to the Liverpool Engineering Society, J. Purves describes an unbreakable water gage. It consists, says *The Engineer*, of a perforated metal tube, and replaces the ¾-in. glass tube in an ordinary water-gage mounting. The diameter of the holes is 3/32 in. On the gage cocks being opened water issues from the hole below the water line in the form of a rapidly diverging white cloudy spray, well defined and readily distinguished. Steam, on the other hand, which issues from the holes above the water line, is only faintly visible and is hardly discernible. The steam jet is almost parallel and quite distinct in character from that of the water; a definite indication is therefore assured. The character of the water jet bears a distinct relation to the thickness of the wall of the tube; by reducing the thickness of the tube, the jet can be made to assume wider proportions. Good results are obtained by thinning the tube down to 3/32 in. round a 3/32 in. diameter hole. Much smaller holes than these, however, will give a perfectly visible jet.

Frank H. Probert, consulting engineer of the United States Bureau of Mines, says that the destruction wrought by Germans in northern France was so "systematic and diabolical" that it will require five years to rehabilitate the coal, iron and steel industry and from 12 to 15 years to return the mines and mills to normal output.

[1] Investigation conducted at the Mellon Institute of Industrial Research, Pittsburgh. This abstract is based on the data thus obtained, as sent out by the Leather Belting Exchange, Philadelphia.

Chicago N. A. S. E. Entertain National President

On his way home from California to the 1919 convention city, Huntington, W. Va., Roderick MacKay, president of the National Association of Stationary Engineers, stopped off at Chicago and attended a meeting of local No. 28 on the evening of May 3. As a directors' meeting had been called for the same date, the Chicago association had the unique honor of entertaining all of the national officers. The return of the president was timed to attend the weekly meeting of No. 1 on May 6.

Mr. MacKay said that he had been impressed favorably with the preparations for the annual convention. The Chamber of Commerce was active and enthusiastic, the city was of about the right size and the convention hall an excellent place for the meeting. Reviewing the affairs of the association, he stated that the organization was in good financial condition due to the increasing prosperity of the official paper. Membership was not so satisfactory. There had been some decrease in the last year or two, but this had been due to the unusual conditions. The president favored isolated membership, particularly in the Western States, where distances between locals were great. These men got the news of the association from the official paper and, when they moved to a city having a local, at once became active members. He also favored junior membership. Get the young man early so that he will become an active member automatically. His enthusiasm and energy are needed, and he in turn will be benefited by the older heads. A firm believer in honorary membership, Mr. MacKay pointed out the mutual advantages of having the employer with them and taking an interest in the work.

"Dad" Beckerleg, the first president of the association, made an appropriate response.

John Lane spoke of the welfare topics to be discussed at the coming convention and the innovation of receiving written discussion from any member to be read at the meeting.

The great interest being taken by the coal men in the coming convention was mentioned by Fred Raven. Already there were twenty coal exhibitors. With brief talks by Joseph O'Connell, John McGrath and Charles Naylor, complimentary to the present officers and trustees, the meeting was closed promptly to allow the national president to make an early start for Topeka, Kan., to attend the first state convention of the season.

Establishes Memorial Scholarships

As a proper war memorial to the more than 8000 employees of the Westinghouse Electric and Manufacturing Co. who entered the service of the Government in the great war, this company has decided to establish a number of technical scholarships. The details of the plan by which this will be done have been given out by President E. M. Herr as follows:

Four War Memorial Scholarships will be established each year under the following general conditions:

a. Candidates will be limited to sons of employees of the Westinghouse Electric and Manufacturing Co. and its subsidiaries, who shall have been employees in good standing for a period of five years.

b. Two of such annual scholarships may be open to the younger employees of the company or its subsidiaries who have been in their service for a period of at least two years and who do not exceed the age of twenty-three.

c. The selection is to be determined by competitive examination to be conducted annually by the company's educational department under the direction of the committee hereinafter provided. The examination is to take into account not only the applicant's academic training and preparedness, but due consideration will be given to personal qualifications, general character and aptitude.

d. Scholarships will entitle the successful candidate to pursue a four years' course in any technical school or college that he may select with the approval of the committee. The scholar may pursue a course in any branch of engineering that he may select.

e. Scholarships will be granted for one year only but will be continued for the full four years provided the scholar pursues a course in any branch of engineering that he may select.

f. Scholarships will be granted for one year only, but will be continued for the full four years provided the scholar maintains the academic and other standards required by the college or institution in which he elects to pursue his course of study.

g. Each scholarship carries with it an annual payment of $500 to be made in two installments and the number of new scholarships will be four each year.

h. A Memorial Scholarship Committee will be established consisting of three vice presidents of the company to whom shall be referred the names and records of the candidates and who shall select therefrom the four successful persons.

Data on Electric Light and Power Plants in Six States

The Bureau of the Census has given out some preliminary figures of the forthcoming report on electric-light and power stations in the various states for the five-year period, 1912-17. Statistics for six states may be summed up as follows:

The number of electric light and power stations in Alabama increased during the period covered from 69 to 82, 10 of the 13 additional plants being municipal and three commercial. The total income increased from $1,257,720 in 1912 to $3,152,709 in 1917, or 150.7 per cent., while the total expenses increased 195.4 per cent. Steam supplied the greater part of the primary power in 1912, but in 1917 56.3 per cent. of the power was derived from water. The aggregate dynamo capacity in 1917 was 128,509 kw., an increase of 425 per cent., as compared with 1912.

Georgia had 176 stations at the close of the period, as compared with 126 at its beginning, 40 of the 60 new establishments being municipal. The total income increased 75.1 per cent., the total expenses 63 per cent., and the aggregate horsepower 42.9 per cent. In 1917 the percentage of power derived from water was 59.8, as compared with 59.1 in 1912.

From 1907 to 1912 the number of establishments in Illinois decreased from 383 to 269, but by the close of 1917 they had increased to 303. Of the 34 new establishments in the period 1912-17, 22 were municipal. The total expenses in 1917 were $37,921,833, and the gross income, $46,245,976, the quinquennial increases being 61 per cent. and 53.9 per cent. respectively. Steam supplied 93.9 per cent. of the horsepower in 1917 and 93.7 per cent. in 1912. The total horsepower increased 62.1 per cent.

The 325 light and power stations in Iowa in 1917 brought in a gross income of $10,240,235, while the total expenses were $8,669,600, the increases over 1912 being 132.4 per cent. and 160.4 per cent. respectively. Water supplied 62.9 per cent. of the primary power in 1917; but in 1912, when there were only 223 plants in the state, 87.4 per cent. of the power was generated by steam. This change was due to the completion of the immense plant on the Mississippi River with dam and power house at Keokuk, Iowa. The increase of 815.3 per cent. in the output of current is also due to the starting up of the Mississippi River Power Co.'s plant, which distributes current not only in Iowa but in several adjoining states.

The statistics for Louisiana show an increase from 50 to 85 stations during the period 1912-17, 22 of the 35 new ones being commercial plants. The total income in 1917—$3,244,789—represented an increase of 42.4 per cent., while the total expenses — $2,459,868 — increased 53.4 per cent. Steam and internal-combustion engines supplied the greater part of the horsepower throughout the period, no water-power plants being reported.

Maine had 93 electric-light and power plants in 1917 as compared with 79 in 1912. Twelve of the fourteen establishments represented in the net increase were commercial, and two municipal. During the five-year period the total expenses increased 52.4 per cent. and the gross income 49.6 per cent. The increase in horsepower during the period was only 9.5 per cent.; water supplied 78 per cent. of the power in 1912 and 76.9 per cent. in 1917.

These statistics cover only municipal and commercial plants. The figures do not take into consideration any idle plants or plants in process of construction.

Engineer Discusses Niagara Power

At the regular meeting of the Detroit Engineering Society, Friday evening, May 2, the speaker, John L. Harper, chief engineer of the Niagara Falls Power Co., gave his audience an insight into the present installations and future development of power at the Falls.

Theoretically, the Falls could develop 6,000,000 hp.; in reality, only 3,600,000 is available, as 40 per cent. of the water would have to pass over the falls to keep the river clear of ice.

The speaker discussed the three principles upon which the governments of the United States and Canada base the amount of water that might be diverted from the Falls for power purposes: (1) The safety of the stream as a national boundary; (2) hindrance to navigation, causing Lake Erie to be lowered; (3) destroying the scenic beauty. His argument against the first item was that the people on the border had lost their fear of the "warlike" Canadians; second, that the water could be diverted for power purposes without affecting the level in Lake Erie by taking it from the pool immediately above the Falls.

In answer to the scenic beauty, he showed a picture of the beautiful American Falls, over which only 5 per cent. of the water flows. With this as a unit of measuring beauty, he suggests that the Horseshoe Falls be reduced to this flow. This would allow 80 per cent. of the water to be diverted for other purposes. However, the 40 per cent. of the water would necessarily have to flow over the Falls to keep the river free from ice, so the scenic beauty could not be destroyed by the power companies even should they divert all the water possible. Again, he brought out the point that something must be done to prevent the Falls from destroying themselves. Between the years 1764 and 1915, the brink of the Falls has retired 900 ft. and at the present time it is falling back at the rate of 10 ft. a year. Economically, he figured, basing the cost of power in terms of coal and distributing the cost of coal over the 1,000,000 visitors per year, that the waste power now added to the scenic beauty is costing $100 a look.

Regarding the scenic effect of the Rapids, it is generally conceded that they are more beautiful when the water is low, due to the more agitated condition of their surface. A peculiar thing was that 75 per cent. of the petitions to retain Niagara and its beauty were signed in the coal-mining districts.

Lantern slides were shown of the different methods used in developing the power, the different plants now operating and the construction of the 100,000 hp. addition to the hydro-electric plant below the Falls on the American side. The 100,000 hp. will be developed by three 33 to 37 thousand horsepower units. Each unit has a concrete base, 40 x 40 x 12 ft. thick, containing 60 tons of steel reinforcing. Great pains were taken to insure the greatest possible efficiency. The penstocks have a bell mouth to allow the water to gather speed before entering the comparatively smaller cross-section, the blades of the waterwheel are given the correct pitch to insure the maximum power and longevity, and the water which leaves the wheel has its velocity retarded from 20 to 4 ft. per sec., the pressure being converted into suction on the wheel. It is expected that a cubic foot of water will develop twenty-one horsepower in these units as compared with twenty in the old plant.

New Publications

EXPORT PACKING OF ENGINEERING MATERIAL

The Engineer Corps, United States Army, has recently compiled and issued an instruction book for export packing of engineering material. The matter contained in the book is the outcome of experience gained in the War Department during the war, where a great many diversified packing problems were encountered, in all of which it was necessary not only to protect adequately the articles shipped, but also to secure minimum space. The book is divided into seven parts: Part I covers Standard Crating Specifications of the War Department; Part II, Standard Boxing Specifications of the War Department; Part III, Standard Specifications for Wire-Wound Boxes; Part IV, Standard Specifications for Baling; Part V, Problems Encountered; Part VI, Supplementary Specifications for Packing for Engineer Material; Part VII, Standard Marking Specifications. Numerous illustrations of boxes and crates are given, and detailed directions for packing boilers, machines, switchboards, etc.

Personals

Joseph V. Santry, of the firm of Schumaker & Santry, of Boston, has been made vice-president of Combustion Engineering Corp., 11 Broadway, New York City.

George A. Harder has been elected president and a director of the Central Foundry Co., New York City, and its subsidiaries. Mr. Harder is also president of the Essex Foundry Co., Newark, N. J.

Lewis Nixon, state superintendent of public works of New York, has been appointed Public Service Commissioner by Governor Smith for the First District of Greater New York, in charge of regulation.

Stephen C. Pohe, who has been general manager of the Penn. Public Service Co. at Clearfield, Penn., has been appointed vice president of the operating companies controlled by the Pennsylvania Electric Co. of New York City, with headquarters at Johnstown, Penn.

William D. Ennis, who has, since his release from military service, been acting professor of mechanical engineering at Columbia University, has been appointed professor in marine engineering in the post-graduate department of the United States Naval Academy.

Lieut.-Col. John J. Swan, who has been connected with the Personnel Branch, Operation Division, of the United States General Staff, and more recently in the Classification Division of the Adjutant General's office, has resigned from the service to become associated with the Prest-O-Lite Co., of Indianapolis, Ind.

J. C. Rockwell has been promoted from local general manager to vice president of the Manila Electric Railroad and Light Co., Manila, Philippine Islands, in charge of the general Philippine affairs of that company. This property is under the operating management of the J. G. White Management Corporation, New York, N. Y.

R. Sanford Riley, president of the Sanford Riley Stoker Co. and the Murphy Iron Works, has returned to his private interests after having completed the organization of a performance section of the Emergency Fleet Corporation. The performance section has charge of all trial trips and follows up the defects developed in service.

Lieut. H. J. Williams, Engineering Division, Ordinance Department, U. S. A., Washington, D. C., has recently been discharged from the service and appointed engineer for the Beacon Falls Rubber Shoe Co., Beacon Falls, Conn. Before entering the service Mr. Williams was consulting and mechanical engineer in New York City and was also on the teaching staff of the Pratt Institute, Brooklyn, N. Y.

Obituary

George Lewis, of Brooklyn No. 8, National Association of Stationary Engineers, died Apr. 3 of pneumonia. Mr. Lewis was recognized as one of the most progressive members of the N. A. S. E. in the Empire State, being particularly identified with the educational activities of the Association. He was past president of Brooklyn No. 8, and at the time of his death was a member of the National Power Plant Costs Committee. He was a member of Melville Council of Universal Craftsmen, Commonwealth Lodge F. & A. M., and many other organizations. He was 42 years of age and held the position of chief engineer of the New York Consolidated Card Company, of Long Island City. He is survived by his widow and a daughter.

Engineering Affairs

Iowa's State Convention, N. A. S. E., at Marshalltown, June 11-13.

Illinois State Convention, N. A. S. E., will be held at Decatur, June 4-6.

New Jersey State Association, N. A. S. E., will hold its yearly convention at Bayonne, June 6-8.

Pennsylvania State Association, N. A. S. E., convention will meet at Pittsburgh, June 26.

Ohio State Association, N. A. S. E., will hold its annual convention at Youngstown, June 19-21.

Kentucky State Association, N. A. S. E., annual convention will take place at Louisville on June 18.

Canadian Association of Stationary Engineers will hold its annual convention at Brantford, Ont., June 24-26. An elaborate program has been arranged.

The Heating and Piping Contractors' National Association will hold its thirtieth annual convention in Atlantic City, N. J., June 12-14, with headquarters at the Hotel St. Charles.

Elmer E. Chambers Council No. 5 and the **Bronx Council No. 16,** of the Universal Craftsmen Council of Engineers celebrated a consolidation of the two associations on May 9 at the rooms of the Elmer E. Chambers Council. There was an entertainment and dancing, and refreshments were served. An orchestra composed of U. S. Navy "boys" furnished the music.

The Association of Iron and Steel Electrical Engineers, Chicago Section, will hold a joint meeting with the American Institute of Electrical Engineers on May 26, at the rooms of the Western Society of Engineers in the Monadnock Building. J. C. Wilson, assistant chief engineer of Cutler-Hammer Manufacturing Co., will give an illustrated lecture on "Measuring Gas Electrically," and B. E. Fernow, of the Cutler-Hammer Co., will give an illustrated lecture on "Lifting Magnet Operation."

The Kansas State National Association of Stationary Engineers held its seventh annual convention at Topeka, May 7-9. There were forty-five delegates present and about one hundred and fifty visiting engineers and ladies. The following officers were elected for the ensuing year: J. W.

Kessler, of Topeka, state president; H. S. Dukes, of Atchison, vice president; C. H. Taylor, of Topeka, secretary; J. R. Stone, of Fort Leavenworth, treasurer; H. F. Thrift, trustee. Topeka was chosen as the place to hold the next convention. In every way the convention was a big success, much of this success being due to the work of Fred Painter, chairman, and J. M. Vansant, retiring secretary.

Business Items

The Ohio Brass Co., Mansfield, Ohio, has moved its Chicago office from 508 Fisher Building to 1217 Fisher Building, 343 South Dearborn St.

H. W. Johns-Manville Co. announces the removal of its Denver (Colo.) office from the Denver Gas and Electric Building into more spacious quarters in the Iron Building, 1021 17th St., with Louis H. Inglee in charge.

L. V. Estes, Inc., industrial engineers and accountants, for a number of years located in the McCormick building, have removed to the Century Building, 202 South State St., Chicago, Ill., where they occupy the entire fifteenth floor.

The American Steam Conveyor Corp., Chicago, announces the appointment of N. B. Stewart as district representative in charge of its St. Louis territory. Offices have been opened at 708 Merchants-La-Clede Building, St. Louis.

The Turner-Wagener Co., Inc., is the new name of what was formerly known as the Turner Advertising Co. J. H. Turner, who was president of the former company, is also president of the new organization. The offices are at 28 East Jackson Boulevard, Chicago.

The York Manufacturing Co. announces that its Philadelphia representatives, Central Construction and Supply Co., with main offices at 2222-26 Arch St., have opened a branch office at 9 West Redwood St., Baltimore, Md. The office is in charge of H. D. Green and John Hill.

The Black & Decker Manufacturing Co., of Baltimore, Md., has established a New York office at Room 2920 Equitable Building, which will be in charge of G. R. Lundane, who will supervise the distribution of the company's products in New York City and surrounding territory, including the State of Connecticut. Mr. Lundane was formerly connected with the Thos. B. Jeffery Co., Kenosha, Wis.

The Wayne Oil Tank and Pump Co., of Fort Wayne, Ind., has recently inaugurated a new consulting and advisory service for oil men, with F. A. Bean, consulting engineer, in charge of the work. Mr. Bean has had a broad engineering experience covering a period of 23 years, 15 of which have been in an executive capacity, and has been affiliated with the oil industry since 1902. The Wayne Co. invites all oil men to make free use of this service.

Trade Catalogs

The Smooth-On Manufacturing Co., Jersey City, N. J., has just issued a new and revised edition of "Smooth-On Instruction Book No. 16." The new edition, like its predecessors, of which hundreds of thousands are in use, is made up of helpful and interesting descriptions of engine and boiler-room repairs of all kinds. These are described by the men who made them in such a way that similar problems can be quickly and economically solved by other engineers. The book is well illustrated by actual photographs and drawings. A copy will be mailed free on request.

The Taylor Instrument Companies, Rochester, N. Y., has issued a general industrial catalog of Tycos instruments containing 422 pages of useful and interesting temperature information. This new publication describes the whole line of Tycos instruments for the indicating, recording and control of temperature. Many special applications are illustrated, showing the manner in which Tycos instruments can be adapted to diverse temperature needs. Practically every instrument manufactured by the companies for industrial purposes is illustrated, and much explanatory matter descriptive of their construction and principles of operation is given.

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$7.80@7.95
Stove	7.95@8.15
Chestnut	8.05@8.35

Bituminous

	Clearfields	Cambrias and Somersets
F.o.b. mines, net tons	$2.15@2.75	$2.75@3.25
Philadelphia, gross tons	4.27@4.95	5.95@5.50
New York, gross tons	4.62@5.29	5.29@5.85
Alongside Boston (water coal), gross tons	6.10@6.85	6.90@7.55

Pocahontas and New River are quoted at $4.70 @5.25 f.o.b. Norfolk and Newport News, Va., for spot coal, and $7.20@8.60 alongside Boston, these prices being on a gross ton basis.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports* are as follows:

	Mine	Company Circular		Mine	Company Circular
Broken	$6.05	$7.90	Pea	4.90	6.65
Egg	5.95	7.80	Buckwheat	3.40	5.15
Stove	6.20	8.05	Rice	2.75	4.50
Chestnut	6.30	8.15	Barley	2.25	4.00

Bituminous

	Spot	Contract
South Forks	$2.90 @ $3.25	$2.95 @ $3.50
Cambria County (good grades)	2.75 @ 2.95	2.95 @ 3.25
Clearfield County	2.50 @ 2.75	2.80 @ 2.95
Reynoldsville	2.50 @ 2.75	2.75 @ 2.95
Quemahoning	2.65 @ 2.85	2.95 @ 3.10
Somerset County (best grades)	2.65 @ 2.85	2.95 @ 3.10
Somerset County (poorer grades)	2.00 @ 2.35	2.50 @ 2.75
Western Maryland	2.25 @ 2.75	2.50 @ 2.75
Fairmont	2.00 @ 2.25	2.35 @ 2.50
Latrobe	2.10 @ 2.25	2.25 @ 2.40
Greensburg	2.25 @ 2.35	2.35 @ 2.60
Westmoreland	2.60 @ 2.75	2.60 @ 2.75
Westmoreland run-of-mine	2.35 @ 2.60	2.35 @ 2.65

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

PHILADELPHIA—The price per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide are as follows:

	Line	Tide		Line	Tide
Broken	$5.95	$7.80	Buckwheat	$3.40	$4.45
Egg	5.95	7.80	Rice	2.75	3.65
Stove	6.20	8.05	Boiler	2.50	3.50
Nut	6.30	8.15	Barley	2.25	3.15
Pea	4.90	6.50	Culm	1.25	2.15

CHICAGO—Current prices per ton for Illinois and Indiana coal are as follows:

Illinois

Williamson, Saline and Williamson Counties	Southern Illinois F.o.b. Mines	Northern Illinois F.o.b. Mines
Prepared sizes	$2.55@$2.75	$3.25
Mine-run	2.35@2.50	3.00
Screenings	1.85@2.20	2.75

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared	Slack and Screenings
Big seam	$2.45	$2.75	$2.40
Black Creek and Cahaba	3.45	3.75	3.05
Jagger - Pratt Corona	2.85	3.05	2.45
Blacksmith	....	5.25	.....

Domestic quoations, slightly increased, are as follows:

	Lump and Nut
Black Creek and Cahaba	3.85@$4.50
Corona	3.40
Jagger	3.50
Montvallo	5.00

ST. LOUIS—The prevailing circular per net ton f.o.b. mines is as follows:

	Mt. Olive and Staunton	Standard
Franklin County		
Prepared sizes, lump, egg, Nos. 1 and 2 nut	$2.75	.....
Williamson County		
Prepared sizes, lump, egg, nut	$2.55	$2.55
Mine-run	2.35	2.20
Screenings	2.20	2.05
3-in. lump	....	2.30
2-in. lump	....	....
		$2.00@2.25
		1.60@1.75
		1.15@1.30
		.....
		1.75@1.90

Williamson-Franklin rate to St. Louis is $1.07; other rates 92½c.

New Construction

PROPOSED WORK

Mass., Athol—The Union Twist Drill Co. will install a steam heating plant in the 4-story, 63 x 190 ft. office and storage building which it plans to build. Total estimated cost, $100,000. Frost & Chamberlain, Slater Bldg., Worcester, Arch.

Conn., Windsor Locks—G. P. Clark Co., Canal Bank, will install a steam heating plant and electric power in the 3-story, 60 x 185 ft. factory which it plans to build. Total estimated cost, $100,000. Ford, Buck & Sheldon, Inc., 60 Prospect St., Hartford, Engr.

N. Y., Athens—The town is having plans prepared by M. Vrooman, Engr., Gloversville, for the construction of a water system, water filters and pumping station, etc.

N. Y., Brooklyn—The Board of Education, 500 Park Ave., will install a steam heating system in the 4-story, 100 x 144 ft. school which it plans to build on West 1st St. Total estimated cost, $299,500. C. B. J. Snyder, Municipal Bldg., New York City, Engr.

N. Y., Brooklyn—I. Miller, 1663 Union St., will install a steam heating plant in the 2-story, 100 x 145 ft. theater which he plans to build at St. John's Place and Utica Ave. Total estimated cost, $150,000. T. Short, 370 Macon St., Arch.

N. Y., Brooklyn—J. Spielberg, 308 Sheffield Ave., has awarded the contract for the construction of a 2-story, 75 x 100 ft. theater which he plans to build on Stone and Pitkin Ave., to the Shoner Building Co., 149 Christopher Ave. A steam heating system will be installed in same. Total estimated cost, $100,000.

N. Y., Brooklyn—The Stone Ave. Realty Co., 50 Court St., will install a steam heating plant in the 1-story, 100 x 100 ft. garage which it plans to build on Fulton and Hendrick St. Total estimated cost, $125,000. M. A. Canton, 373 Fulton St., Arch.

N. Y., Buffalo—The city will install an American Radiator system and two low water line boilers in the 3-story, 60 x 125 ft. detention home which it plans to build on East Ferry St. Estimated cost, $100,000. H. L. Beck, City Arch.

N. Y., Buffalo—The city will install an American Radiator system in the 2-story, 175 x 400 ft. barn which it plans to build on Hudson St. Total estimated cost, $300,000. H. L. Beck, City Arch.

N. Y., Holley—The Holley Cold Storage, Fruit & Produce Co. is in the market for ice-making machinery. Estimated cost, $6000.

N. Y., Jamaica—H. & J. Merkel, 450 Fulton St., Brooklyn, will install a steam heating plant in the 2-story, 75 x 100 ft. factory which they plan to build on Chichester Ave., here. Total estimated cost, $125,000. L. Allmendinger, 20 Palmetto St., Brooklyn, Arch.

N. Y., Long Island City—The Board of Education, 500 Park Ave., New York City, will install a steam heating plant in the 3-story, 100 x 108 ft. Public School No. 3 which it plans to build on Colonial Ave., between Livingston and Meter St. Total estimated cost, $200,000. C. B. J. Snyder, Municipal Bldg., New York City, Engr.

N. Y., New Dorp—St. John's Guild, 103 Park Ave., New York City, will install a steam heating plant in the 3-story nurses' home which it plans to build here. Total estimated cost, $150,000. York & Sawyer, 50 East 41st St., New York City, Engr.

N. Y., New York—A. Brocener, Engr., 110 West 40th St., will install a steam heating system in the 16-story, 150 x 200 ft. hotel which he plans to build on 5th Ave., near 50th St. Total estimated cost, $500,000. Owner's name withheld.

N. Y., New York—The Hudson Motor Car Co. of New York, 1842 B'way, will install a steam heating plant in the 10-story, 100 x 100 ft. store and office building which it plans to build at 62nd St. and Amsterdam Ave. Total estimated cost, $550,000. E. J. Muller, 103 Park Ave., Arch.

N. Y., New York—The McCormick Co., Engr., 41 Park Row, will install a steam heating system in the 2-story bakery which he plans to build at 165th St. and Park Ave. Total estimated cost, $100,000. Owner's name withheld.

N. Y., New York—R. T. Rane, Jr., Chicago, Ill., will install a steam heating plant in the 4-story warehouse which he plans to build at 1996-2010 Park Ave. Total estimated cost, $175,000. Starrett & Van Vleck, 8 West 40th St., Engr.

N. J., Trenton—The Taylor Provision Co., Perrine Ave., plans to build a 2-story, 50 x 70 ft. refrigerator plant. Estimated cost, $20,000. J. O. Hunt, 114 North Montgomery St., Arch.

Va., Hampton Roads—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will receive bids until May 26 for installing a high pressure air and water system at the Submarine Base here. Estimated cost, $43,000. Specification No. 3883.

Ala., Bessemer—The Board of Revenue of Jefferson County, Birmingham, will install a steam heating plant in the court house and jail which it plans to build. J. W. Gwin, Pres.

Ohio, Cleveland—The Arjo Realty Co., c/o J. Laronge, Williamson Bldg., will install a steam heating plant in the 5-story commercial hotel which it plans to build on East 66th St. and Carnegie Ave. Total estimated cost, $750,000. Lehman & Schmidt, 210 Electric Bldg., Engr.

Ohio, Cleveland—The Bricklayers' Association, 2416 East 9th St., will install a steam heating plant in the 3-story, 61 x 140 ft. garage and club rooms which it plans to build at 2101 East 21st St. Total estimated cost, $100,000.

Ohio, Cleveland—The Cleveland Heights Methodist congregation, Lee Rd. and Euclid Heights Blvd., will install a steam heating system in the 2-story church which it plans to build. Total estimated cost, $100,000.

Ohio, Cleveland—The Cleveland Masonic Clubs, East 6th St. and Superior Ave., will install a steam heating plant in the 3-story, 220 x 700 ft. Masonic temple which they plan to build at 3515 Euclid Ave. Total estimated cost, $500,000.

Ohio, Cleveland—The Eleventh St. Co., Williamson Bldg., plans to install a steam heating plant, in connection with remodeling the Lennox Building on East 9th St. and Euclid Ave., and building a new addition to same. Total estimated cost, $150,000.

Ohio, Cleveland—W. G. Montgomery, 1420 Alameda Ave., Lakewood, will install a steam heating plant in the 3-story theater which he plans to build on West 32nd St. and Bridge Ave. Total estimated cost, $150,000.

Ohio, Cleveland—C. Shane, c/o the Liberty Theater, 10315 Superior Ave., will install a steam heating plant in the 5-story store and office building which he plans to build on East 4th St. and Euclid Ave. Total estimated cost, $150,000.

Ohio, Cleveland—N. I. Stone, Rockefeller Bldg., will install a steam heating plant in the 4-story, 73 x 198 ft. theater and stores which he plans to build at 10618 Euclid Ave. Total estimated cost, $250,000. A. G. Yost, Rockefeller Bldg., Arch.

Ohio, Cleveland—W. Taylor & Son Co., Euclid Ave. and 6th St., will install a steam heating plant in the 9-story addition to its store which it plans to build. Total estimated cost, $500,000.

Ohio, Cleveland—W. Vretman, 413 Engineers' Bldg., will install a steam heating plant in the 2-story commercial building which he plans to build on West 117th St. and Lorain Ave. Total estimated cost, $125,000. Whitworth & Johnson, 413 Engineers' Bldg., Engr.

Ohio, Martin's Ferry—The city plans election Aug. 12 to vote on $450,000 bonds for new water works and electric lighting plant. C. Lash, City Engr.

Ohio, Stacyville—The Power Engineering Co., 510 Corn Exchange, Minneapolis, Minn., plans to build a new concrete dam and power plant here. J. A. Webber, Stacyville, Engr.

Mich., Battle Creek—The Advance Pump & Compressor Co., North Division St., is in the market for a centrifugal pump for heating systems. C. A. Flinn, Supt.

Mich., Detroit—The Detroit Seamless Steel Tube Co., Jefferson Ave. and 19th St., plans to build a 70 x 100 ft. heating plant including coal crusher and powdered coal system, in connection with the proposed manufacturing units on Warren Ave. Total estimated cost, $3,000,000.

Mich., Detroit—The North Woodward Methodist Episcopal Congregation, c/o W. E. N. Hunter, Arch., 1306 Chamber of Commerce, will install a steam heating plant in the 2 story, 180 x 250 ft. church which it plans to build on Woodward, between Marston and Chandler Ave. Total estimated cost, $500,000.

Mich., Detroit—The Woodward Theatres Co., 306 Breitmeyer Bldg., has awarded the contract for the construction of a 70 x 160 ft. theatre, store and office at 158-164 Gratiot St., to the F. Farrington Co., 202 Scherer Bldg. A heating plant, consisting of combination system with motor and fans, air compressors and sprinkler system will be installed in same. Estimated cost, $60,000. H. Koppin, Pres.

Wis., Sheboygan—The Congregational Congregation, c/o E. Hammett, 1209 North 7th St., will install a central heating plant to furnish heat for the 2 story, 90 x 150 ft. church which it plans to build on North 7th St. Total estimated cost, $100,000. W. C. Weeks, 720 Ontario Ave., Arch.

Ia., Mapleton—The city will soon award the contract for the construction of a pump house and laying pump suction line. Estimated cost, $8000. W. E. Standeven, 414 Bee Bldg., Omaha, Engr.

Minn., Hastings—The State Board of Control or C. H. Johnson, Engr., 715 Capital Bank Bldg., St. Paul, will receive bids until August 1st for the completion of a 1 story, 45 x 140 ft. power plant here. Estimated cost, $125,000.

Minn., Hibbing—The Oliver Mining Co., Wolvin Bldg., Duluth, will install steam heating equipment in the 5-story central addition to its commercial hotel. Total estimated cost, $200,000. S. S. Ramsey, Wolvin Bldg., Duluth, Engr.

Kan., Clayton—The city voted $10,000 bonds for the construction of a transmission line from Clayton to Norcatur.

Kan., St. John—The city voted $45,000 bonds to improve the water and light system by installing a power plant. Noted Feb. 11.

Kan., Topeka—R. L. Gamble, State Arch., will receive bids until May 27 for installing a vacuum steam heating and water supply system in the State Capitol building.

N. D., Hensel—The Village Board will soon award the contract for one 15 hp. force feed oil engine, one water tank suitable for same, one 50-gal. supply tank and one 10 kw. dynamo. L. J. Wilker, Village Clk.

Okla., Newkirk—The city plans election soon to vote on $110,000 bonds for the construction of electric light plant and service lines.

Ariz., Florence—S. M. Bailey, City Clk., will receive bids until May 28 for the construction of a water works and electric light plant. Estimated cost, $80,000. Noted Feb. 25.

Ore., Coquille—The Johnson Saw Mill Co. plans to electrify its plant and install two 75 hp. motors and one smaller motor.

Cal., Covina—The Covina Citrus Association plans to build an orange packing house and precooling plant to have a capacity of 80 cars daily. Ice plant machinery will be installed in same. Estimated cost, $125,000. W. W. Bennett, Mgr.

Cal., Modesto—The Modesto Gas Co. plans to build a new gas generating unit, install two new purifiers, build a 300,000 cu.ft. steel gas holder and extend gas mains to new section of the city. Estimated cost, $65,000.

P. I., Cavite—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will receive bids until May 26 for installing power plant equipment here. Estimated cost, $90,000. Specification No. 3871.

CONTRACTS AWARDED

Conn., Hartford—Swift & Co., 60 North Market St., Boston, Mass., has awarded the contract for the construction of a 2-story, 78 x 100 ft. cold storage plant on Church St., here, to J. H. Grozier Co., 721 Main St. Estimated cost, $90,000.

N. Y., Utica—The Board of Education has awarded the contract for installing a heating plant at the J. E. Brandegee School to H. C. Petersen & Co., 20 Oneida St., for $16,973.

Que., Valleyfield—The Montreal Cottons, Ltd., 263 St. James St., Montreal, has awarded the contract for four 51-in. vertical water turbines of 50 hp. each, to operate with 12-ft. head at 100 r.p.m., to W. Hannetor & Co., 479 Reid St., Peterborough, Ont.

You Will Find

The Latest Equipment Bargains
The Big Business Opportunities
The Best Positions Vacant
The High-Grade Executives
The Live-wire Operatives

in the

SEARCHLIGHT SECTION

The "opportunity center" of the power plant field

SEE PAGES 77 TO 84